



INTEGRATED BIOMASS LOGISTICS CENTRES FOR THE AGRO-INDUSTRY

Basic analysis of targeted agricultural sectors

D6.2.1 Country report Greece

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Approvals

Author/s	Company
	CERTH
Contributor	INASO
Task Leader	WFBR
WP Leader	WFBR
Reviewer	CIRCE

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	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

ABBREVIATIONS

EBITDA: Earnings Before Interest, Taxes, Depreciation and Amortization

EBIT: Earnings Before Interest & Tax

GDP: Gross Domestic Product

ELSTAT: Hellenic Statistic Authority

HSI: Hellenic Sugar Industry

IBLC: Integrated biomass logistics centre

KEOSOE: Central Cooperative Union of Wine Products

OECD: Organisation For Economic Co-Operation and Development

OMWW: Olive Mill Waste Water

SPEL: Association of Olive Kernel Oil Producers of Greece

TPOMW: Two-phase olive mill waste

PARTNERS SHORT NAMES

CIRCE: Fundación CIRCE

WFBR: Wageningen Food & Biobased Research

ZLC: Fundación Zaragoza Logistics Centre

CERTH: Ethniko Kentro Erevnas Kai Technologikis Anaptyxis

RISE: RISE Research Institutes of Sweden AB

CREA: Consiglio per la Ricerca in Agricoltura e L'analisi dell' Economia Agraria

APS: Agroindustrial Pascual Sanz S.L

NUTRIA: Anonymi Biomichaniki Etairia Typopiisis Kai Emporias Agrotikon

LANTMÄNNEN: Lantmännen Ekonomisk Forening

Processum: RISE Processum AB


SCO-OPS: Cooperativas Agro-Alimentarias de España. Sociedad Cooperativa

INASO: Institouto Agrotikis Kai Synetairistikis Oikonomias INASO PASEGES

AESA: Agriconsulting Europe S.A

UCAB: Association Ukrainian Agribusinessclub

UBFME: University of Belgrade. Faculty of Mechanical Engineer

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

EXECUTIVE SUMMARY

The current report investigates the following main agricultural sectors of the Greek economy: olive oil, sugar industry, wine industry, grain supply chain and the vegetable oil extraction. Each sector chapter consists of two main parts: i) general information on the sector, such as production process, productivities, current state of the sector and degree of innovation and ii) opportunities of the IBLC concept to be implemented on each sector/ existing agro-industries. IBLC is a concept that diversifies regular activity of the agro-industry on both the input (feedstock) and output (biocommodities, intermediates).

The olive oil and wine sectors are considered as the most important sectors for the Greek agricultural economy not only because of their annual production but also because of the vast amounts of by-products that both of them produce during their production process. These residues can be used as feedstock for the production of solid biofuels (e.g. pellets from olive or wine prunings), biochemicals from olive and wine by-products etc.

Furthermore, the sugar industry sector also generates residues and by-products, which can be used as biomass feedstock – primarily, sugar beet pellets and molasses. The first, in particular, is used as animal feed, whereas the second one is used as feedstock for the production of bioethanol. Unfortunately, it should be mentioned that the sugar industry in Greece faces many challenges considering its economic strength due to the economic crisis, thus, the quantities of the products and by-products have been decreased for the last years.

Both, the vegetable oil extraction sector and the grain chain sector, produce significant amounts of residues. These residues can be also used as feedstock for the production of solid biofuels (e.g. straw pellets, briquettes.). However, a large portion of these by-products is used as raw material for the feed and fodder sector or as bedding material. Another agricultural sector in Greece that could be investigated regarding the IBLC concept implementation is the feed and fodder. However, the scarcity of available statistical data and the difficulty to achieve communication with stakeholders from this sector, made unfeasible to analyse this sector on the current report.

For a more detailed summary on every sector, Chapter 7 “Summary analysis of the country” can be consulted, where all the information can be found.


	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

TABLE OF CONTENTS


1	Introduction	9
2	Olive Oil Sector	11
2.1	Profile of the olive oil sector	11
2.1.1	Production	11
2.1.2	Volume of the sector	14
2.1.3	State of the sector	16
2.1.4	Typical size of the companies	18
2.1.5	Distinctive facilities of the sector	19
2.1.6	Degree of innovation	20
2.2	Opportunities IBLC	20
2.2.1	Sector related residues	20
2.2.2	Potential synergies & benefits	23
2.2.3	Market developments	24
2.2.4	Non-technical barriers	25
3	Sugar Industry	27
3.1	Profile of the sugar industry sector	27
3.1.1	Production	27
3.1.2	Volume of the sector	28
3.1.3	State of the sector	29
3.1.4	Typical size of the companies	31
3.1.5	Distinctive facilities of the sector	31
3.1.6	Degree of innovation	32
3.2	Opportunities IBLC	33
3.2.1	Sector related residues	33
3.2.2	Potential synergies & benefits	34
3.2.3	Market developments	34
3.2.4	Non-technical barriers	34
4	Wine sector	35

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

4.1	Profile of the wine sector	35
4.1.1	Production	35
4.1.2	Volume of the sector	37
4.1.3	State of the sector	39
4.1.4	Typical size of the companies.....	39
4.1.5	Distinctive facilities of the sector.....	40
4.1.6	Degree of innovation	40
4.2	Opportunities IBLC.....	40
4.2.1	Sector related residues.....	40
4.2.2	Potential synergies & benefits	42
4.2.3	Market developments	44
4.2.4	Non-technical barriers	44
5	Grain chain	45
5.1	Profile of the grain sector.....	45
5.1.1	Production	45
5.1.2	Volume of the sector	46
5.1.3	State of the sector	47
5.1.4	Typical size of the companies.....	48
5.1.5	Distinctive facilities of the sector.....	49
5.1.6	Degree of innovation	49
5.2	Opportunities IBLC.....	49
5.2.1	Sector related residues.....	49
5.2.2	Potential synergies & benefits	50
5.2.3	Market developments	50
5.2.4	Non-technical barriers	51
6	Vegetable oil extraction.....	52
6.1	Profile of the vegetable oil extraction sector	52
6.1.1	Production	52
6.1.2	Volume of the sector	53
6.1.3	State of the sector	54
6.1.4	Typical size of the companies.....	55

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

6.1.5	Distinctive facilities of the sector	55
6.1.6	Degree of innovation	56
6.2	Opportunities IBLC.....	56
6.2.1	Sector related residues.....	56
6.2.2	Potential synergies & benefits	57
6.2.3	Market developments	57
6.2.4	Non-technical barriers	58
7	Summary analysis of the country.....	59
8	References	68
9	Annex A. Consulted stakeholders	72

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

1 INTRODUCTION

The current report constitutes part of the AGROinLOG project “Demonstration of innovative integrated biomass logistics centers for the Agro-industry sector in Europe” (#727961) and is within the scope of the Task 6.2 “Basic analysis of targeted agricultural sectors”. AGROinLOG supports the demonstration of Integrated Biomass Logistic Centres (IBLC) for food and non-food products, evaluating their technical, environmental and economic feasibility. This report aims at providing an overview of the current state of the sectors and evaluating them with respect to the IBLC related topics.


The following chains are considered in this report, due to their importance for the Greek agricultural economy, the volume of residues and by-products produced every year and the opportunities they represent to implement IBLC concepts: olive oil sector, sugar industry, wine sector and grain supply chain. These sectors are also thought to have unexploited synergies in terms of underused production, processing or storage capacities. In addition to the abovementioned sectors, the vegetable oil extraction sector was investigated. However, due to lack of available data, the sector is not described in the same detail as the other sectors.

A basic analysis, depending on the available public data sources (official statistics from the Hellenic Statistical Authority and relevant Ministries, general information from different studies and papers, webpages of main stakeholders and industries involved in the sectors), has been performed for each sector. Moreover, additional information was gathered from the selected stakeholders in order to have a clearer picture of the current state of each sector. More specifically the stakeholders that were consulted are listed in Annex A.


More specifically on this report, basic information for each sector is analyzed. The analysis of each sector is divided into two main parts:

- One part regarding general information on the profile of the sector. Information about the annual productivities, the production process, the volume, economic strength / state, typical size of the companies, distinctive facilities and R&D activities of the sector are presented.
- Another part regarding the IBLC opportunities in each sector. Information is provided on each sector’s residues, potential synergies of existing equipment during idle times, market use of sector’s residues and non-technical barriers that can be encountered when the IBLC concept will be implemented.

During the desk study performed in order to find data on the abovementioned Greek sectors, several challenges were encountered due to the limited statistic data available on the residues of the Greek sectors, economic data of the sectors etc. When applicable, in order to overcome difficulties such as quantifying the amount of residues of each sector, worldwide literature and scientific papers were used to estimate these amounts. In addition, difficulties were faced in

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

retrieving data of the sector from the stakeholders, since they could not be shared some detailed data for confidentiality reasons.

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

2 OLIVE OIL SECTOR

2.1 Profile of the olive oil sector


2.1.1 Production

The main input for the olive oil sector is the fruit of the olive tree, while the main outcome are various categories (based on quality) of olive oil. According to Annex I of the Community Regulation 865/04 "on the Common Organization of the Market in Olive Oil and Table Olives", (EU Legislation, 2004) the quality categories of olive oil and olive-pomace oil authorized to be sold and marketed within the Community are defined as follows (from highest to lowest quality ranking, IOC, 2017):

- 1) Virgin Olive Oil: olive oil obtained from the fruit solely by mechanical or other physical way that do not lead to alterations in the oil.

Virgin Olive Oil is classified with the following names:

- Extra Virgin Olive Oil: virgin olive oil which has a free acidity, expressed as oleic acid, of not more than 0.8 grams per 100 grams and other characteristics that correspond to the requirements of International Olive Council standards.
 - Virgin Olive Oil: virgin olive oil which has a free acidity, expressed as oleic acid, of not more than 2 grams per 100 grams and other characteristics that correspond to the requirements of International Olive Council standards.
 - Ordinary Virgin Olive Oil: virgin olive oil which has a free acidity, expressed as oleic acid, of not more than 3.3 grams per 100 grams and other characteristics that correspond to the requirements of International Olive Council standards.
- 2) Refined Olive Oil: olive oil obtained from virgin olive oils by refining methods, which do not lead to alterations in the initial glyceridic structure. It has a free acidity, expressed as oleic acid, of not more than 0.3 grams per 100 grams and other characteristics that correspond to the requirements of International Olive Council standards (International Olive Council, 2006).
 - 3) Olive Oil: olive oil consisting of refined olive oil and virgin olive oils. It has a free acidity, expressed as oleic acid, of not more than 1 gram per 100 grams and other characteristics that correspond to the requirements of International Olive Council standards.
 - 4) Crude Pomace Oil: olive pomace oil whose characteristics correspond to the requirements of International Olive Council standards. It is intended for refining for use for human consumption, or it is intended for technical use.
 - 5) Refined Pomace Oil: oil obtained from crude pomace oil by refining methods, which do not lead to alterations in the initial glyceridic structure. It has a free acidity, expressed as oleic acid, of not more than 0.3 grams per 100 grams and other characteristics that correspond to the requirements of International Olive Council standards.

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

- 6) Pomace Oil: oil comprising the blend of refined olive pomace oil and virgin olive oils fit for consumption as they are. It has a free acidity of not more than 1 gram per 100 grams and other characteristics that correspond to the requirements of International Olive Council standards.

After the harvesting, the olives are transported to the olive oil mill where oil is produced by cold or hot pressing of the olive fruit. The mills carry out the first phase of olive oil production, which is then either directly available for consumption in bulk or promoted to commercial enterprises for resale in Greece or abroad, or is supplied to processing and/or standardization companies.

In general, there are three main types of olive oil mills depending on the production process:


- Traditional olive mills, where hydraulic presses are used;
- Three-phase centrifugal mills, where the extraction process produces olive oil, pomace (~60% moisture content) and olive mill waste water (OMWW); and
- Two-phase centrifugal mills, which produce olive oil and wet pomace (Two-Phase olive mill waste/ TPOMW, ~70 % moisture content).

Between the two types of centrifugal extraction, two-phase mills are both more productive (in terms of the amount of extracted olive oil) and more environmentally friendly. The main difference is that two-phase mills require less water during the extraction process, leading to lower energy costs, less water is wasted during the process and a higher extraction rate of olive oil (output/input ratio around 20 % for two-phase and 18 % for three-phase mills) achieved. Overall, the average processing cost of two-phase mills is about € 0.16 per kg of olive oil compared with € 0.19 per kg of olive oil in three-phase mills (National Bank of Greece, 2015). Moreover, the higher concentration of natural antioxidants enhances the quality of olive oil produced in two-phase mills and makes it more resilient during storage.

Greek olive oil mills mostly use two-phase technology. The stakeholder of the Association of Olive Kernel Oil Producers of Greece (SPEL) consulted estimates that there is a 60/40 split between the two-phase and the three-phase systems in Greece. The promotion of two-phase mills is expected to continue, aiming for higher productivity combined with improved environmental protection (National Bank of Greece, 2015). The current trend in Greece is for three-phase olive mills to turn into two-phase olive mills as there are corresponding legislations that support and push towards this conversion.

Analytically the whole process of olive oil production, as it can be seen in Figure 1, is generally the following:

- Receiving the fruit: After harvest, the olives are transported to the mill, where they are temporarily stored until they are processed.
- Defoliation – Washing: Placement in a picking hopper of olives, transport by conveyor or endless screw to a leaf removal, where leaves and other foreign bodies are removed and then washed to remove other impurities.
- Crack-milling of olives: Extrusion of the fruit and production of olive oil (or olive paste).

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18


- **Malaxation:** The olive oil is blended in softeners to achieve the merging of the oil traps into larger drops of oil.
- **Extraction of olive oil:** In the traditional process (hydraulic press), a liquid / water mixture is first extracted, which is separated in a subsequent phase by centrifugation to obtain the olive oil.
- **Three-phase centrifugation:** In this step a significantly amount of hot water is inserted to wash the oil. Separation of solid residue (olive cake) from the other two liquid phases occurs in the decanter.
- **Vertical Centrifugation:** The final separation of olive oil from the vegetation water.
- **Two-phase centrifugation:** Same process as in three-phase centrifugation but the horizontal centrifugation is performed without the addition of water. There are two output streams as olive oil is separated from solid phase (TPOMW-wet pomace)

The olive mill wastes (pomace) are sent to pomace mills where further processing occurs for retrieving edible pomace oil. Pomace mills are necessary steps in the olive oil value chain. They use as raw material the crude olive cake produced by the olive mills, dry it and extract the residual oil (usually using chemical solvents, such as hexane), known as pomace oil. Moreover, they produce one or more solid biofuels originated from the stone, flesh and skin of the olive fruit (along with some small quantity of residual oil). Depending on the process adopted, these can be olive stones (mostly the pit part of the olive fruit), exhausted olive cake (mostly the flesh part of the olive fruit) or “combined” fractions.

Concerning the pomace oil mills there are two main stages of pomace oil production:

- **Drying process:** During the drying process, the olive pomace is propelled into large cylindrical dryers, heated and rotated. With this procedure, the large amount of water is reduced and the oil is easier to be removed.
- **Distillation process:** The pure hexane (C_6H_{14}) is used for the distillation process of the olive pomace, which literally “rinses” the oil from it. The oil-hexane mixture is then propelled into special distillation tanks where the two components are completely separated. After this stage, the pomace oil is ready for storage.

The whole process of oil production is depicted in Figure 1. The olive oil production processes are presented in blue boxes, the main by-products of the whole olive oil chain are in red boxes and the final edible products in the green boxes.

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

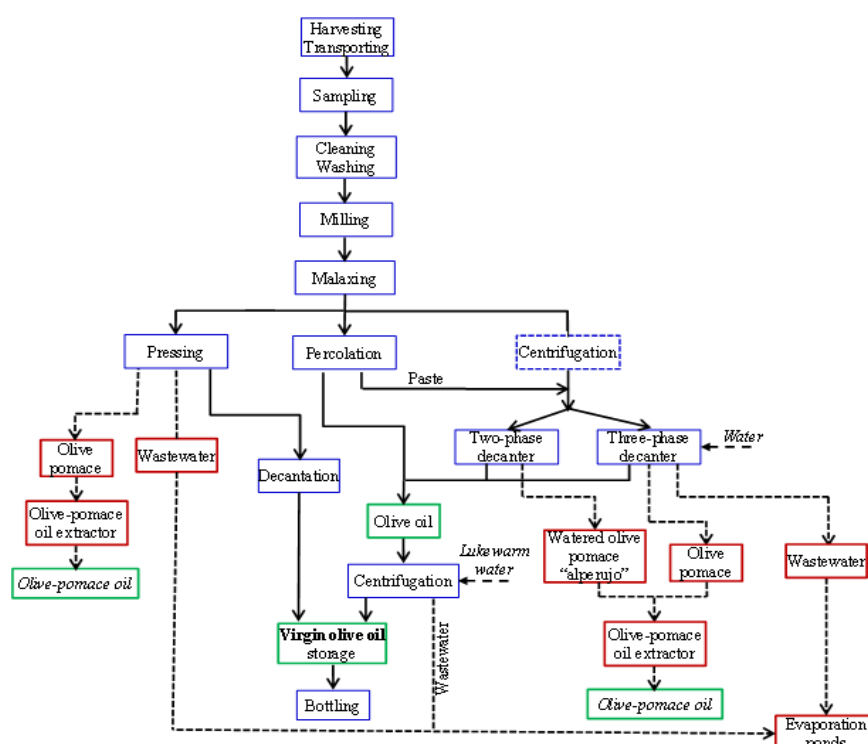


Figure 1. Schematic process of olive oil production in Greece. Source: (AOCS Lipid Library, 2017)

2.1.2 Volume of the sector

Greece is the third olive oil producer in the world, after Spain and Italy with a typical annual production ranging from around 300 to over 400 kt (in a very productive year) of olive oil depending on the olive oil year. Table 1 presents the olive oil production and cultivated areas of olive groves from 2012 to 2014 (ELSTAT, 2014).

Table 1. Olive Oil Production and cultivated areas of olive groves from 2012-2014. Source: (ELSTAT, 2014)

Olive Oil Production and Cultivated Area (2012-2014)			
	2012	2013	2014
Olive Oil Production (kt)	331.9	291.4	251.4
Cultivated Area (10 ³ x ha)	807	797	823

Table 2 shows the production of olive oil for year 2014 across the geographical regions of Greece. The majority of olive oil is produced in Peloponnese, Crete and Western Greece (ELSTAT, 2014).


	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

Table 2. Olive Oil Production based on geographical areas in Greece 2014. Source: (ELSTAT, 2014)

Olive Oil Production based on Geographic Regions for 2014		
	Olive Oil Production (kt)	Percentage (%)
Peloponnese	78.3	31.2
Crete	60.7	24.1
Central Greece	28.9	11.5
Northern Greece	11.4	4.5
Western Greece	62.4	24.8
Aegean Islands	9.7	3.9
Total	251.4	100

The value of domestic olive oil production is estimated at around € 800 million contributing to 0.4 % of Greece's GDP per year (average during 2010-2015), compared to 0.3 % of GDP for the Spanish industry and 0.1 % for the Italian (National Bank of Greece, 2015). Furthermore, in the latest years, the olive oil sector contributes more than 0.4 % on the domestic GDP (personal communication, ELSAP, 2017). Olive oil is one of the most significant economic sectors in Greece. However, according to the sector analysis of the National bank of Greece, olive oil production is expected to decline to 280 kt in 2020 (National Bank of Greece, 2015).


Considering the organization of the sector, Greece has a high proportion of small (and largely cooperative) mills that amount to 2,500 (National Bank of Greece, 2015). Stakeholders in the olive-milling sector however indicate that the total number of olive mills in Greece may be even higher, up to 4,000.

Table 3 provides the difference in the number of olive and pomace mills in the three main olive oil producing countries in the EU: Spain, Italy and Greece (MoRE project, 2008). Greece has around 35 pomace mill facilities (according to the members' directory of SPEL). Furthermore, according to stakeholder's feedback (personal communication, NUTRIA, 2017), in Greece there are 7 large scale refineries and another 3-4 small scale companies that refine olive and pomace oil.

Table 3. Number of olive mills and pomace mills in the three main olive oil producing EU countries. Source (MoRE project, 2008)

Olive and pomace mills		
Country	Olive mills	Pomace mills
Spain	1,722	50
Italy	4,743	40
Greece	2,500	35

Figure 2 presents the geographical distribution of olive mills around Greece. The majority of olive mills (36.5 %) are located in Peloponnese, whereas Crete follows with 23.3 % of the total national olive mills.

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

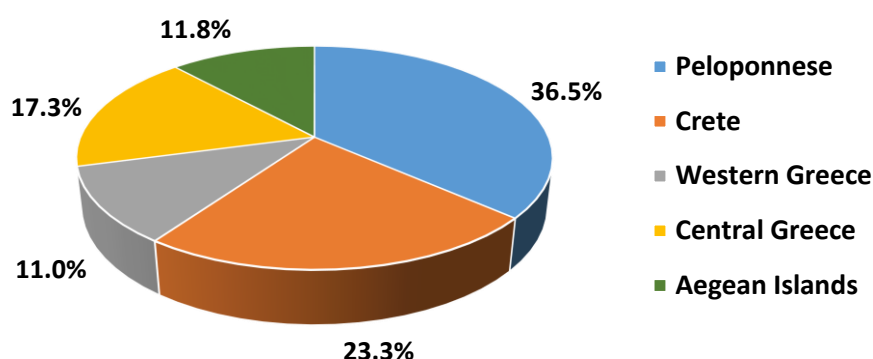


Figure 2. Geographical distribution of olive mills in Greece. Source: (Prodosol, 2009)

2.1.3 State of the sector

Regarding the economic strength of the olive oil sector, it is worth to mention that only the 27 % of the Greek olive oil is distributed for domestic consumption or exported as a branded product while most of it is sold in bulk form (National Bank of Greece, 2015). Domestic consumption absorbs about two thirds of olive oil production in Greece while the rest is exported (100,000 to 135,000 t). Due to lack of an effective export strategy and relevant sector organization, most of the exported quantity (about 70 %) is exported to Italy in bulk form where it is mixed with different origin olive oil and re-exported as an Italian brand olive oil. Figure 3 below presents the main destinations of the Greek olive oil production and some statistic data for the main olive oil producers (National Bank of Greece, 2015).

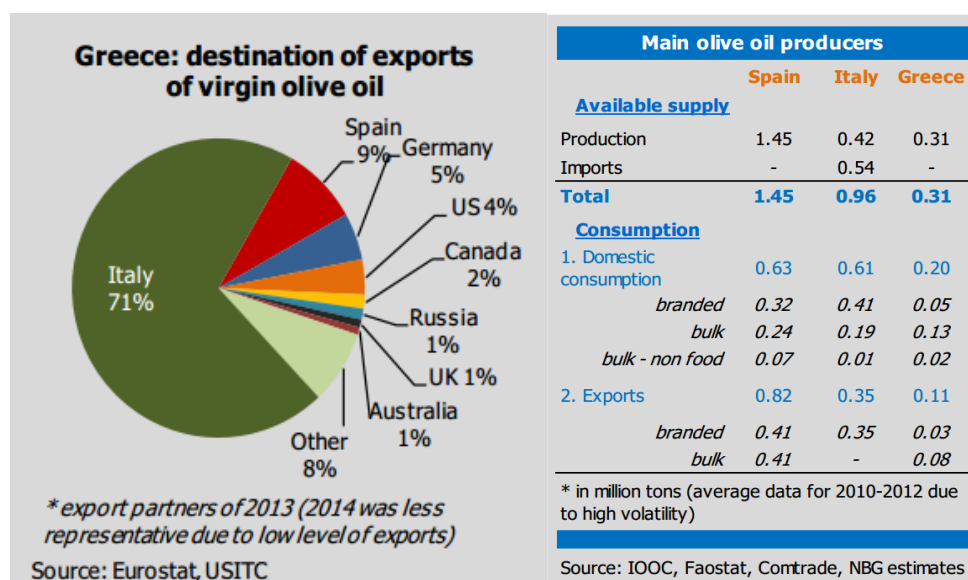


Figure 3. Statistic data of exports of the main olive oil producers. Source: (National Bank of Greece, 2015).

The total sales for the large, medium and small-sized industries amounted to 832.7 million euros for 2014 (decreased by 16.2 million euros in value and 2 % in percentage compared to 2013). Based on the statements of the interviewed stakeholders, the current state of the olive sector in Greece

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

is in good weather after the very low productivities and profits of years 2011-2014. Table 4 summarizes the financial figures for the olive oil sector industries for 2011-2014.

Table 4. Consolidated financial figures of olive oil and pomace industries. Source: (inr.gr, 2014)

Consolidated financial figures of olive oil and pomace industries for 2011-2014				
	2011 (k€)	2012 (k€)	2013 (k€)	2014 (k€)
Total assets	684,773	948,911	917,652	942,892
Sales	631,721	837,686	848,844	832,679
Gross profit	95,929	125,327	140,338	133,394
EBITDA	51,305	64,512	74,536	66,920
Net profit	5,206	6,011	13,437	10,527

Table 5 presents the economic sizes of the top ten industries of the olive sector in Greece based on the sales (inr.gr, 2014). The main business line of most of these industries is the standardization of olive oil (and pomace oil) and the marketing of olive oil products; ELSA S.A. is the only company on the list whose primary activity is the operation of pomace mills.

Table 5. Economic size of the ten biggest Olive Oil Industries in Greece, mainly standardization industries. Source: (inr.gr, 2014)

Economic Size Of The Biggest Olive Oil Industries In Greece, 2014				
Company Name	Location	Total Assets (k€)	Sales (k€)	EBITDA (k€)
INTERCOMM FOODS S.A. AGRICULTURAL PRODUCTS	Larisa	70,154	77,556	10,951
MINERVA S.A. OIL OPERATIONS	Athens	70,265	75,798	2,757
KORE S.A. OLIVE PRODUCTS – FOODSTUFFS	Athens	45,370	65,549	2,813
DEAS S.A. OLIVE - AGRICULTURAL PRODUCTS	Chalkidiki	39,213	37,904	6,496
NUTRIA S.A. STANDARDIZATION OF AGRICULTURAL PRODUCTS	Fthiotida	33,458	36,948	1,537
KONSTANTOPOULOS OLYMP S.A. OLIVE PROCESSING	Katerini	32,229	34,793	5,928
AGROVIM	Messinia	14,796	28,874	1,057
AGROTIKI S.A. OIL OPERATIONS	Attiki	22,160	17,108	-791
ELANTHI S.A. FOODSTUFFS	Attiki	23,738	7,837	1,977
ELSAP S.A. OIL OPERATIONS	Argolida	19,334	3,026	-844

Furthermore, Table 6 presents ten pomace mills in Greece with the highest sales for year 2011.


	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

Table 6. Economic size of the ten biggest Pomace Mills in Greece based on sales. Source: (inr.gr, 2014)


Economic Size Of The Biggest Pomace mills in Greece, 2014				
Company Name	Location	Total Assets (k€)	Sales (k€)	EBITDA (k€)
AGROTIKI SINETAIRISTIKI RETHIMNOU S.A. (A.S.E.A.R.) ¹	Rethimno	18,074	9,838	583
PIRINAS S.A.	Messinia	3,421	3,741	444
ELSAP S.A.	Argolida	19,334	3,026	-844
CHATZELIS K. S.A.	Lakonia	3,420	2,846	220
ILEIA OIL MILLS	Ilia	5,198	2,182	94
MESSINIAKI	Messinia	4,547	2,024	-27
EAIOURGIKI VOIOTIAS PYRINELAIOURGEIO S.A.	Voiotia	3,630	1,598	131
ELEOURGIKI KENTRIKIS ELLADAS S.A. (EL.K.E.)	Lamia	6,438	1,587	97
KOUFAKI AFOI ELAIOURGIAI ARGONAULIAS	Argolida	2,826	1,564	208
ELAIOURGIAI MAGNISIAS MICHAEL KOUFAKIS	Magnisia	2,474	1,384	-601

¹A.S.E.A.R. produces and trades feed and fodder, apart from pomace oil

2.1.4 Typical size of the companies

The typical size of the Greek companies in this sector differs from the Spanish or the Italian ones. In Greece, olive mills are mostly owned by cooperatives controlled by farm owners (50 % of oil olive production). Greek olive mills are relatively small and thus they lack economies of scale and access to international distribution networks. Greek olive mills have an average annual capacity of 200-230 t of olive oil compared with 120 t in Italy and 750 t in Spain. Regarding the size of the pomace mill, a typical pomace mill in Greece has a capacity of treating around 450-500 t pomace /day (personal communication, ELSAP, 2017).

There is no exact data about the amount of workers that are employed in the olive sector in Greece. The stakeholder interviewed stated that a typical olive mill has 5-6 employees, all of them seasonal employees (personal communication, Agios Konstantinos Cooperative, 2017). Assuming that in Greece, there are 2,500 olive mills and considering a typical size of them, the total amount of seasonal employees working in olive mills is around 15,000. Furthermore, the stakeholder from the pomace oil sector estimated that in each pomace mill there are 5-6 permanent workers and around 25 seasonal workers during the olive oil production period (personal communication, SPEL, 2017). Thus, it is estimated that in the 35 pomace mills in Greece, there are employed 210 permanent workers and 875 seasonal workers. Moreover, Figure 4 presents the labour force productivity in the Greek olive sector, regarding the farming and harvesting of olives. Based on this figure, the labour productivity in Greece is estimated at 19 t of olives per employee according to the statistical

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

data from the National Bank of Greece (National Bank of Greece, 2015). Taking into consideration that a typical annual production of olives in Greece is 2,646,000 t, it is estimated that the seasonal employees working in the farming/ harvesting of olives amount to 140,000 workers.

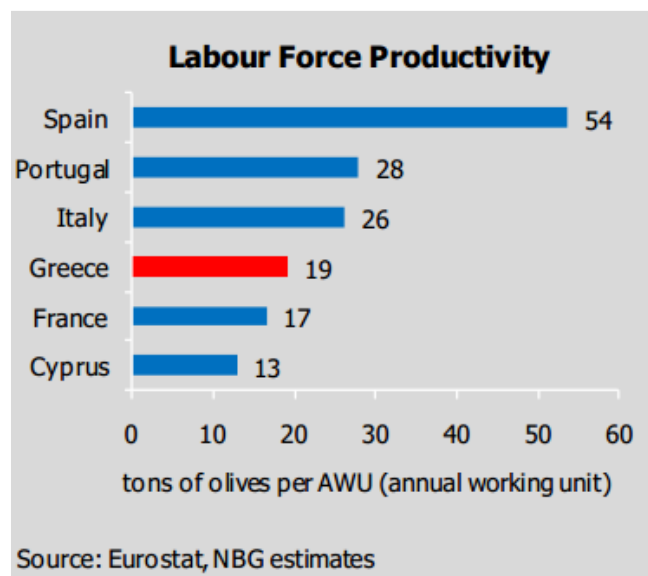



Figure 4. Labour Force Productivity. Source: (National Bank of Greece, 2015)

2.1.5 Distinctive facilities of the sector

The facilities that are used for the olive oil and the pomace oil production are in full operation during the months from September to March with the exception of a few areas (e.g. Corfu) where the olive season is larger due to local peculiarities. In some cases, during summer months, pomace mills operate with edible olives, that have been expired, and extract pomace oil from them (personal communication, Loukision Cooperative, 2017). In overall, there is a lot of idle time for implementing an IBLC concept in the olive oil sector. Facilities such as storage areas, dryers, centrifuges or purification systems can also be used for different purposes. For example, the storage areas can be used in order to store prunings or mulched material from olive or vine prunings that are produced from the olive trees or vineyards of the nearby areas.

Moreover, the centrifuges and the purification systems can be used from the vegetable oil extraction sector in order to extract their main products. Furthermore, dryers used in pomace mills, can find various applications during their idle times like drying other materials such as olive prunings, cereals etc.

From the interview with the representative of Association of Olive Kernel Oil Producers of Greece (SPEL), he stated that the facilities of pomace mills could be exploited during idle times and treat other raw materials such as alfalfa, clover etc. However, investments on the modifications of current equipment and/or purchase of new equipment would be essential for such implementation. For example, she stated that a pomace mill in Messologi, Western Greece, during its idle months, it treats alfalfa. This feedstock has a similar moisture content with two-phase

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

pomace, around 80 %. Thus, when the pomace mill does not operate with pomace, it dries alfalfa and packages it.

2.1.6 Degree of innovation

As mentioned before, about 40 % of the olive oil mills in Greece use the three-phase centrifugation method for the extraction of olive oil. However, more and more olive oil mills have the tendency to change their process from the three-phase to the more sustainable two-phase centrifugation.

Two-phase centrifugation is the best solution in the olive oil process treatment, because it is more eco-friendly than the three-phase system (by saving water, reducing the volume of liquid waste, etc.) and for that reason it is proposed for the new olive oil industries. Moreover, the two-phase centrifugation advantages over the three-phase are the following:

- It produces much smaller quantity of olive oil wastes than the three-phase system.
- The quality of the virgin olive oil that is produced by the two-phase is better than that of the three-phase system, mainly regarding the content in polyphenols and antioxidants.
- The two-phase systems do not require additional quantities of water to produce the olive oil paste by reducing the operating cost of the installation.
- The energy demand of the two-phase systems is smaller, due to the lower amount of olive paste that is going to be processed.
- In the two-phase systems, no extra centrifuge is required for the treatment of the extra produced fluids because they are recycled.

Concerning all the above properties of the two-phase centrifugation method, the latest prevailing tendency in Greece is the alteration of the remaining three-phase centrifugation systems to two-phase systems in the olive oil mills. This trend does not occur only because of the advantages of two-phase over three-phase technology but also because of the national legislation that forces olive mills to this change.

The interviewed stakeholder mentioned that there are some olive companies that invest in R&D activities, however it is a minority. Furthermore, he stated that because the olive sector industries (mainly pomace mills) are out of the development law and national grants, the R&D activities are very limited.

2.2 Opportunities IBLC

2.2.1 Sector related residues

The three-phase olive mills during the extraction process of the oil produce, apart from the olive oil, two residue streams, an aqueous solution with a solid content of no more than 6 % called olive oil waste water and the olive pomace which is a solid stream residue. The latter is sent to pomace mills for further processing whereas the olive wastewater is disposed. In case of the two-phase olive mills, there are two output streams, one stream of olive oil and another with the two-phase olive

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18


mill waste (TPOMW), a solid stream residue with high moisture (~70-80 %) that is sent to pomace mills for further processing. Pomace mills have as input the residues produced from the olive mills. Pomace mills, after extracting the pomace oil from the pomaces, they produce one or more solid biofuels originated from the stone, flesh and skin of the olive fruit. Depending on the process adopted, these can be olive stones (mostly the pit part of the olive fruit), exhausted olive cake (mostly the flesh part of the olive fruit) or “combined” fractions.

Table 7 presents some estimated values of the wastes produced in the olive mills and pomace mills. It should be noted that for the estimation of the annual produced products and residues it was assumed that the annual olives production for olive oil in Greece is 1,571 kt (value for year 2014, Eurostat, 2014) and also that the 60 % of the olive mills in Greece use the two-phase technology. From the above percentages, we can assume that the input for the mills that use the two-phase technology is 942.6 kt olives and 628.4 kt olives for the ones that use the three-phase technology. In Table 7 a clearer picture of the mass balance of the products/ residues along the olive and pomace mills is depicted.

Table 7. Mass balance of olive and pomace mill products estimated based on year 2014 olives production

Estimated Olive and Pomace Mills Products and Residues for 2014		
	Two-Phase (60%)	Three-Phase (40%)
Olive Mill	Procedure	
	Olive Fruits Input (kt)	942.6
	Olive Oil Production (kt) ^a	188.5
	Olive Mill Residues	
	Olive Mill Waste Water (ML) ^b	345.6 - 439.8
Pomace Mill	Olive Pomace (kt), sent to pomace mills ^c	754.0 ^d
	Pomace Mill Products	
	Pomace Oil (kt)	10
	Exhausted Olive Cake (kt)	273.8 ^f
	Exhausted Olive Cake (kt - available to the market after covering own consumptions of pomace mills)	70.0

^a 20% of live fruit is converted into olive oil; ^b Retrieved from <https://www.agroenergy.gr>; ^c 80% of olive fruit is converted into pomace in two-phase mills, 50% in three-phase mills; ^d 68% wt moisture and 5% wt d.b. oil content; ^e 52% wt moisture and 3% wt d.b. oil content; ^f 15% wt moisture and 1% wt d.b. oil content. Source of all values: Communication with Greek stakeholder, SPEL

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

Apart from the above-mentioned residues, the olive sector produces prunings. Currently, in Greece, there are two ways that olive prunings are treated. The most frequent use is that of burning them in open fires and thus, having negative impact on the environment and increasing the risk of fires. The other way, less used, is to mulch the prunings onto the soil of the olive groves. Currently, there are no recent national surveys based on field data regarding the availability of APPR biomass in Greece. The standard reference study for prunings from olive groves derives from a study of Apostolakis et al. from as back as 1987. This study presents residue-to-product ratios (RPR) for the prunings produced from various types of permanent crops in Greece. The statistical data of crop productivity on which the pruning results are based dates from 1980. Another, way to estimate the pruning potential is via the biomass supply tool developed in the FP7 S2Biom project. This tool forecasts the pruning potential from permanent crops for 2020 and for all the EU-28 countries. The evaluation is based on applying country specific residue-to-surface ratios (RSRs) for certain tree crop types (olive, vineyards, citrus and fruit trees) to projections of the surface area used for the cultivation of these crops, as taken from the CAPRI model. Moreover, a third method for estimating the olive pruning potential at national level was performed via Biomasud Plus H2020 project and CERTH calculations. In this method, the pruning potential estimation is based on RPR from various references. The calculations for this method is based on the productivities of the crops in year 2014.

The moisture considered in all methods is 35 % wt for olive prunings. The olive pruning potential is presented in Table 8 based on these methods.


Table 8. Potentials (kt of dry matter per year) for olive prunings in Greece according to several data sources

Potentials for olive prunings (kt of dry matter per year)			
Source	Reference Year	Methodology	Olive Prunings
Apostolakis et al.	1980	RPR + national production statistics	1,135
Biomasud Plus	2014	- // -	1,718
S2Biom	2020	RSR + CAPRI surface projections	1,165

From the three methods, the national pruning potential is estimated in a range of 1.13-1.72 dry Mt. Finally, in the framework of uP_running project (Grant Agreement No 691748) on-field measurements of olive pruning production were performed in several olive groves around Greece. Based on these on-field measurements, Apostolakis et al. and Biomasud's RSR values are more in line with the RSR values found from the on-field measurements for olive trees.

In addition, another residue deriving from the olive sector is that of olive stones. Olive stones amount to 8.3 % of the weight of the olive fruit (dry basis) (Rodero et al., 2017). However, actual production volumes depend on the production systems employed. Only a limited number of companies in Greece perform the separation of olive stones from the olive cake. The stones typically end up in the exhausted olive cake produced by the pomace mills. Based on some initial discussions with such producers, CERTH estimates that the volume of production of separated olive stones in Greece is around 5,000 – 7,000 t.

Finally, another residue related to the olive oil sector is that of the olive leaves that remain unexploited. The olive leaves can be retrieved either during the harvesting of olives or during the

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

preparation of olives prior to the olive oil extraction. Olive leaves are rich in phenolic compounds that can be exploited in pharmaceutical or cosmetics industry.

2.2.2 Potential synergies & benefits


The residues from three-phase olive mills are wet pomace and OMWW (olive mill wastewater). Wet pomace is sent to pomace mills for further exploitation whereas the OMWW have to be disposed. OMWW possesses a double nature. It is a strong pollutant and at the same time a possible source of valuable components, such as polyphenols, flavonoids, anthocyanins, inorganic trace elements, etc., that could be isolated. Several treatment options have been considered including physical, physicochemical, biological, thermal technologies and combinations thereof, as well as other combined approaches that could improve decontamination efficiency.

- Physical treatment, which involves the separation of different phases through mechanical means. When used, so far, the physical treatment of OMWW is unable to reduce alone the organic load and toxicity of the wastes to acceptable limits.
- Physicochemical treatment, which involves the use of additional chemicals for their neutralization, flocculation, precipitation, adsorption, chemical oxidation and ion exchange.
- Biological treatment, which involves the use of microorganisms in order to break down biodegradable chemical species, which are present in OMWW, is considered environmentally friendly and effectively in cost. The actual type of microorganisms depends on the treatment option, i.e. anaerobic or aerobic.
- Thermal treatment involves the concentration of OMWW by reducing their water content and total volume (Prodosol, 2017).

Olive mill wastes contain an important amount of phenolic compounds, such as the exhausted olive cake from the two or three-phase pomace. In this sense, wet pomace after being treated in the pomace mills to produce pomace oil, can be used to extract the phenolic compounds (mainly hydroxytyrosol). These phenols can find several applications in cosmetics, pharmaceuticals or as anti-oxidants. However, to perform such processes, additional investments are needed for the pomace mills.

Moreover, the olive prunings as residues of the olive sector can be exploited. They can be used as raw material for the production of pellets or as fuel for covering the energy demands of the mills. However, new investments are needed for the harvesting equipment of the pruning. Continuously, dryers that exist in the pomace mills can be used in order to dry the prunings before exploited, offering a synergy in the idle times of the pomace mills.

Finally, Fernández (Fernandez-Bolanos, 2006) proposed a technological scheme (as seen in Figure 5) in order to exploit all the valuable compounds found in the olive wastes of two-phase mills. According to his strategy-technology, valuable phenols, chemical, bioethanol, biofuel etc. can be retrieved from the olive mill wastes. Thus, this is an example of the integrated valorisation of agro

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

residues in an existing agro-industry by expanding traditional processes with additional biorefinery steps.

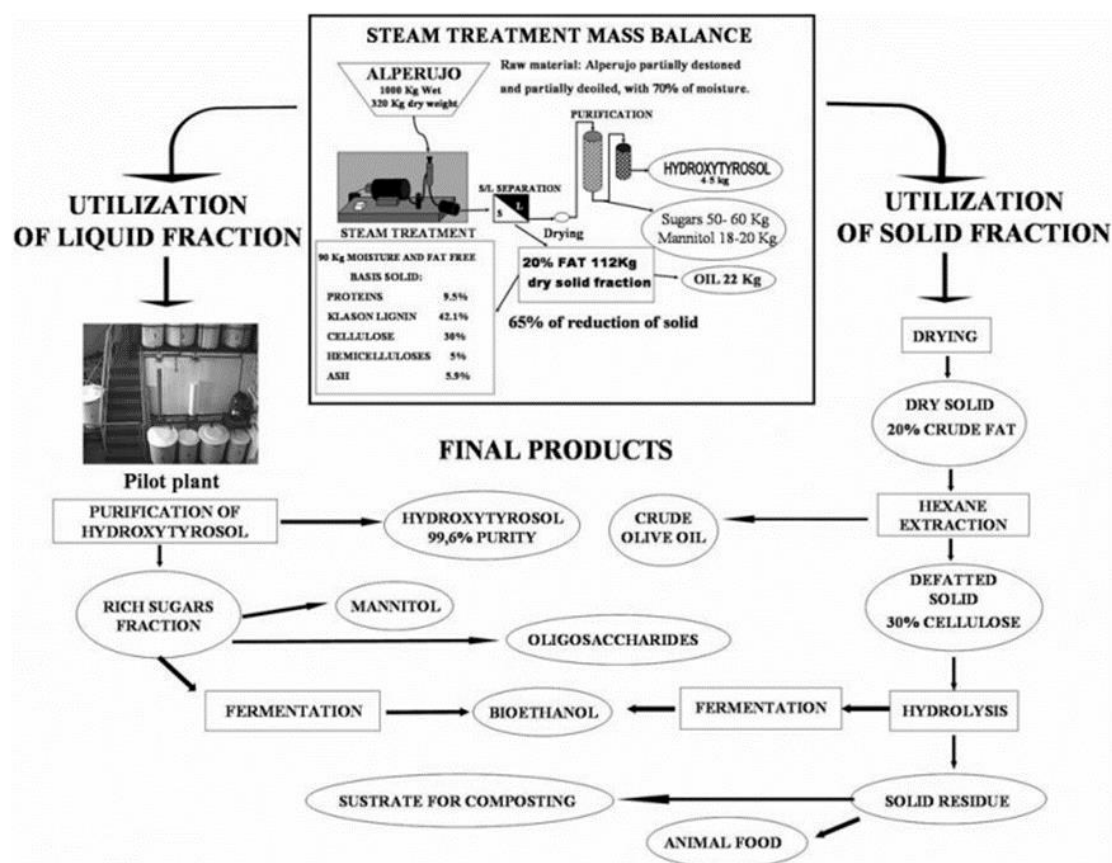



Figure 5. Strategy for an integral recovery and revalorization of olive mill waste- alperujo (TPOMW). Source: (Fernandez-Bolanos, 2006)

2.2.3 Market developments

Usually the exhausted olive cake and olive stones, produced from the pomace mills as by-products, are sold as a fuel in the solid fuel market. Olive stones are much better fuel than exhausted olive cake due to lower moisture and ash content. However, in practice, the separation of olive stones by the Greek mills is rare. In most cases, all solid by-products end up in a single fraction, which is marketed as “pirinoksilo”, as it is known in Greek. The exhausted olive cake is mainly used as fuel for covering the own consumptions of the pomace mill. In addition, exhausted olive cake is used as fuel for space heating in the residential sector. It contributed to 2.34 % (ELSTAT, 2013) of the biomass consumption for residential heating. In 2017, the market price for the exhausted olive cake was in the range of 70 €/t (VAT included). However, the exhausted olive cake is exclusively consumed in rural areas as in urban areas its odour causes complaints. A specific requirement that legislation imposes on exhausted olive cake and relative fractions used for non-industrial applications in Greece is that their oil content should not exceed 2 % wt on a dry basis (Ministerial Decree 198/2013).

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

On the other hand, the OMWW can be used on soils and crops as a fertiliser, due to the organic matter and nutrients contained that could improve arid soils. However, the properties of soil (e.g. texture, nutrient, organic matter content and productivity) can be damaged due to the continuous application. OMWW can also be used as feedstock for biogas production. Almost 80 % of organic compounds in OMWW are suitable for anaerobic digestion. Theoretically, a yield of 37 m³ of methane per m³ of OMWW could be achieved (Tsagaraki, 2005). Potential feedstock for biogas production is also the TPOMW. In the frameworks of AGROinLOG project, the biogas production from the exhausted olive cake from TPOMW, via anaerobic digestion will be investigated.


In addition, both TPOMW and OMWW have the ability to be transformed into products for its use in the pharmaceuticals industry as well as in the food industry, by recovery of antioxidants. The olive fruit is rich in simple and complex water-soluble compounds with potential antioxidant properties. The most important of them are polyphenols, flavonoids, anthocyanins, tannins, oleanolic acid and maslinic acid. Polyphenols in olive wastes have shown to be antioxidant, antibiotic, antimicrobial, and antifungal activity. Formulas of these olive-derived substances can be used as nutrition supplements or skin cosmetics. Due to their antimicrobial properties, they are also used as antimicrobial agents in detergents and rinsing and cleaning agents. Hydroxytyrosol is the most active component of them and it can be used as a food preservative and in pharmacology and cosmetology in topical preparations with anti-aging and anti-inflammatory action. Oleanolic acid regulates cholesterol levels in blood and balances body weight. Maslinic acid has been widely investigated during the last years and it seems to possess anti-inflammatory and antihistaminic activity. It also could be used in pharmacology as an inhibitor of AIDS virus (Tsagaraki, 2005).

Another interesting market for the olive residues is the animal feed industries. The exhausted olive cakes can be used in animal feeding, as they are rich in oil, carbohydrates, and proteins.


Finally, olive prunings can be used for producing pellets or chips that can be sold as solid biofuels or used directly for power and/or heat production in plants. An example is Fiusis power plant, located in Puglia, Italy. Fiusis is a small-scale power plant (1 MWe) producing electricity exclusively from olive tree prunings. It is considered the first plant of its kind to use exclusively olive prunings as a fuel source (Up_running project). In addition, other products can be produced from olive prunings such as particle boards used in the construction sector. Another residue that could be exploited from the olive sector is that of leaves. Leaves also contain a high amount of phenolic compounds. However, the extraction of phenols and the exploitation of leaves for added value products has to be further investigated.

2.2.4 Non-technical barriers

According to the information received from the interview with the stakeholder (personal communication, SPEL, 2017) one non-technical issue that has emerged these years is the reluctant behaviour of the Greek citizens regarding the potential exploitation of the current facilities (olive and pomace mills) for other activities during their idle periods. In many regions, most of the citizens are against to the current operation of the pomace mills because of the odour and smoke (due to the high moisture of the feedstock) that comes out of the pomace mills. Thus, the stakeholder

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

consulted is pessimistic about how residents will accept continuous operations of such facilities by implementing the IBLC concept. Furthermore, the stakeholder stated that the fact that pomace mills are constantly absent from national funding and support schemes makes it difficult for themselves to invest on such implementations. Continuously, some additional barriers were identified regarding the exploitation of residues of the olive chain. The synergy of launching the exhausted olive cake, as a residue from the pomace mill, in the residential solid fuel market for consumption in urban areas would find several barriers such as its high ash content and intense odour. Finally, another barrier/ problem of the sector is that due to the production of olives which is climate-dependent, technologies for exploiting by-products and residues of the oil sector have not yet been developed.

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

3 SUGAR INDUSTRY

3.1 Profile of the sugar industry sector

3.1.1 Production

The main product in this sector is sugar, which is contained in the beet. A sugar factory's task consists in extracting sugar out of the beet with a chemical transformation.

Mainly the beet contains (Figure 6):

- 14-17 % sugar
- 76-78 % water
- 4-5 % insoluble dry ingredients (marc)
- 2-3 % soluble dry ingredients (nitrogenous and non-nitrogenous organic and inorganic components).

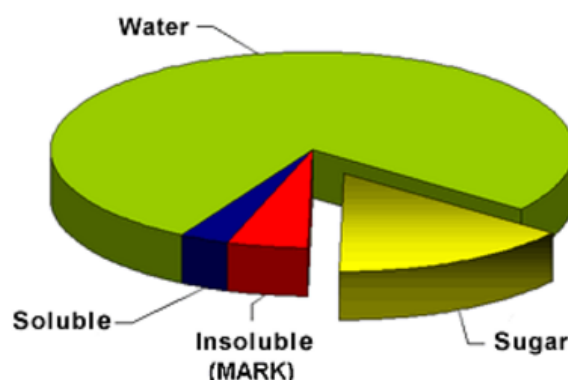



Figure 6. Main ingredients of a sugar beet. Source: (Hellenic Sugar Industry)

The insoluble dry ingredients called marc (consisting of cellulose, lignin, pectine, pentozane), consist the main component of the by-product called pulp (fresh or dry, or in compressed form as pellets). The soluble dry ingredients, after removing approx. 1/3 of the juice in the purification stage, are found again in the molasses, where they bind also a part of sugar.

The sugar production is a fairly complicated process. The industrial production in Greece follows the stages below:

1. Acceptance, washing and beets cutting: Beets are carried over from a collection point that ranges up to 70 km around the sugar factory.
2. Diffusion: Diffusion is the process where the sugar contained in the bits is received. This process is based on the principle of osmosis. The sugared juice is collected at one edge, while the diffused bits, called pulp, are recovered at the other edge and are used after a compression and possible drying as cattle feed.

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

3. Pre-liming, liming: The sugared juice derived from diffusion contains 12-13 % sugar and - 85 % foreign materials called non-sugars. A portion of these foreign materials is removed.
4. Saturation (carbonation): Carbon dioxide is introduced into the limed juice where the sugar-lime breaks down and a sediment of calcium carbonate is formed.
5. Filtration: The sediment of calcium carbonate lays down on the filters. The sweet juice is clear and contains ~1.6 % non-sugars, ~12 % sugar and ~86 % water (thin) juice.
6. Evaporation: In order to remove the water, wherein sugar is dissolved, the thin juice gets through a stage of successive evaporation.
7. Crystallization: The juice is condensed to an increasing extent in apparatuses operating under vacuum. It thereby reaches a stage of super-saturation (Hellenic Sugar Industry, 2009).

The whole production process is shown in Figure 7.

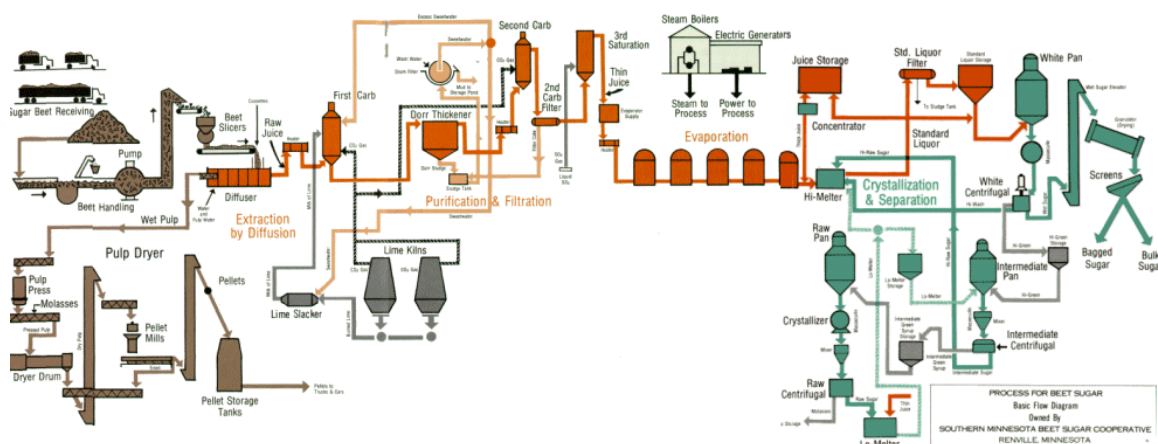


Figure 7. Main stages of the sugar production process. Source: (Hellenic Sugar Industry, 2009)

3.1.2 Volume of the sector

The Hellenic Sugar Industry SA (HSI) is the sole sugar producer in Greece. The main activity of the company is the production and trade of sugar, as well as the trade of its by-products. The company produces white crystal sugar whereas in the course of production, a set of by-products is also being produced which, following a proper processing, are made available in the market. In concrete terms, the products produced and traded by the company are as follows:

- White crystal sugar
- Molasses
- Sugar-beet pulp pellets
- Fresh pulp
- Beet seed

For many years, the HSI has been producing at its 5 factories all the amount of sugar needed to cover all domestic needs (320,000 t/year). For this production, the company supported the cultivation of hundreds of thousands acres (about 450,000) with contracts with over 6,000

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

producers for the production of sugar beet. However, in February 2006, EU agriculture ministers approved a radical reform of the sugar sector in the EU and all EU countries have been forced to reduce their production of sugar by at least 50 %. For Greece, the new ceiling amounts to 158,702 t/year. As part of the implementation of the regulation, farmers were compensated not to grow beets, and the industries were compensated by stopping their operation and dismantling productive sugar refineries. All of this finally has led to an intense fluctuation of the sugar production due to the unstable number of beet growers as it can be seen in Table 9 for the last years.

Table 9. Beet growers, cultivated area and sugar production from 2010-2014. Source: (private communication, HSI, 2017)


Beet growers, cultivated area and sugar production in Greece for years 2010-2014			
Year of production	Beet growers	Cultivated area (ha)	Sugar Production (kt)
2010	4,144	13,367	77,2
2011	2,133	5,791	38,3
2012	3,100	9,309	54,7
2013	1,875	5,799	40,2
2014	2,360	7,400	53,4

3.1.3 State of the sector

As mentioned above, HSI is the only sugar producer in Greece and since 2010 it has regained a large part of the internal market which had been lost, because of the economic problems during the past few years. HSI also owns two factories in Serbia where around 60,000 t of sugar is produced (in 2008). In this framework, the company exports important quantities to Bulgaria with sugar from the neighbouring factory of Orestias. The by-products of sugar, like molasses and sugar beet pellets, cover the needs of industries and cattle-breeders in the internal market while the additional quantity is exported to the countries of the European Union or even to Third Countries (Hellenic Sugar Industry). In the following Table 10 HSI sugar sales from year 2004/2005 until 2008/2009 are shown.

Table 10. Sugar sales from 2004 to 2009 Source: (Hellenic Sugar Industry, 2009)

Sugar Sales from 2004 to 2009					
	2004/2005 (t)	2005/2006 (t)	2006/2007 (t)	2007/2008 (t)	2008/2009 (t)
Yearly production	259,500	310,178	184,806	78,388	157,375
Production sugar sales	155,549	346,307	247,840	88,215	169,783
Importation sugar sales	75,051	58,579	65,712	82,052	56,729
Total sales H.S.I.	230,600	404,886	313,552	170,267	226,512

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

Despite the fact that white crystal sugar is the staple of the company, in order to cover any additional demand, sugar is also imported from the EU countries. Moreover, the company is engaged in producing beet seed out of sugar beets which, after a proper processing, is being sold to the beet-growers while some quantity is being exported to seed producing companies abroad.


In Table 11 the economic analysis of the years 2006-2009 regarding the production and trading of the company is shown. For the period 2006-2009, 89.77 % of the total sales of HSI came from selling products of own production, whereas only the 10.23 % of these total sales came from trading goods. The total sales of sugar amounted to 88.19 % of the total sales (Hellenic Sugar Industry, 2009).

Table 11. Economic analysis of the last year's production in the Hellenic Sugar Industry. Source: (Hellenic Sugar Industry, 2009).

Economic analysis of Hellenic Sugar Industry, 2006-2009				
Products:	2006/07 (M€)	2007/08 (M€)	2008/09 (M€)	Three-year Total (M€)
Sugar	150.9	66.9	84.6	302.4
Molasses	6.9	5.4	5.1	17.5
Dry pulp	8.7	6.0	4.4	19.2
Fresh pulp	1.1	0.8	0.8	2.7
Beets Seeds	0.9	0.9	1.4	3.2
Services (sprayings)	3.2	1.3	1.9	4.0
Other services	0.4	0.5	0.7	1.6
Sales of other materials	2.6	2.6	4.0	9.2
Imported goods:	2006/07 (M€)	2007/08 (M€)	2008/09 (M€)	Three-year Total (M€)
Sugar	29.9	44.9	42.8	117.6
Molasses	0.3	0.9	0.8	2.1
Seeds	0	1.1	1.0	2.1
Total	205.2	131.5	147.7	484.4

As it can be concluded from the economic data of the three years (2006-2009), HSI has a downturn. Despite its tries to remain the main sugar producer in Greece, the Hellenic Sugar Industry is becoming year by year even more unable to respond to the national needs. Reason for this is the fact that farmers prefer other intensive crops (cotton, corn, sunflower, etc.), which (mainly cotton) enjoy higher subsidies from beet growing.

From interviews with a Hellenic Sugar Industry stakeholder, the bad weather in which the sugar sector is in Greece can be justified from 2014 year's production numbers. In 2014, the annual turnover amounted to 90.6 M€ with an annual sugar production of 53,400 t coming from a cultivated area of 7.400 ha of sugar beets. Furthermore, according to the stakeholder the current year (2017) is the worst year regarding production of sugar and selling it. Indicatively, the market

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

value of sugar for the last production year is only at 315 €/t. This shows that the last year was the worst production year of all times.

3.1.4 Typical size of the companies

Before it was decided to close the Larissa and Xanthi factories, HSI used to have two fully equipped units (the first in Xanthi and the second one in Larissa), and three sugar factories (Plati, Serres, Orestias) as well as one seed processing factory. Both of the two equipped units are now out of order and only the second unit in Larissa is used from the company as a beet gathering area and packaging unit. On the other hand, only the two sugar factories in Plati and Orestias are in full function, with the Plati sugar factory to have a daily beets processing capacity of 8,000 t and a potential of sugar output at 100,000 t per year. Continuously, the sugar factory in Orestias has a daily beets processing capacity of 5,400 t and around 70,000 t sugar output per year. The sugar factory in Serres has not been completely shut down but its operation is suspended. Every year, the board decides whether the sugar factory in Serres will work or not (personal communication, Hellenic Sugar Industry, 2017). According to the feedback from the stakeholder, the amount of permanent workers that are employed in the Hellenic Sugar Industry are around 220 people and around 280 more employees in the two subsidiaries companies in Serbia. The workforce is doubled during the production months (September to January) by hiring seasonal employees.


The geographical breakdown of the company's operating units is shown in Figure 8.



Figure 8. Geographical breakdown of the sugar units in Greece. Source: (Hellenic Sugar Industry, 2009)

3.1.5 Distinctive facilities of the sector

The sugar facilities are in full operation from September to January. Many times, the operation starts from August. The rest of the year, maintenance of the equipment and facilities occurs in order

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

for the facilities to be ready and deal with the next year's import of raw material. The equipment and the plant maintenance process takes too long (personal communication, Hellenic Sugar Industry, 2017). However, there is still idle time for implementing IBLC concept. This is justified by last year's production period (2017) which took place from September until only October.

However, there are facilities that can find further use in other biomass-treating processes such as storage areas, feed handling, dryers, evaporators, or pelletizer for producing pellets from different kind of biomass feedstock. Due to the complexity of sugar production process, it is uncertain whether an equipment within the production chain can be exploited by itself.

Furthermore, the current sugar facilities operate with HACCP (Hazard Analysis and Critical Control Points) for food safety and as a result, it is important to know the raw material that will be used in the above mentioned facilities and harmonize their use with the current operations rules of the facility.

3.1.6 Degree of innovation


Research in combination with continuous quality control and genetic improvement were main activities of the company. Hellenic Sugar Industry is the sole producer in Greece giving special emphasis to the support of all its productive procedures through the most modern technological advances.

One of the most remarkable programs of the company was the Genetic improvement for the creation of new sugar beet varieties acclimatized to the agro-climatic peculiarities of Greece. The extensive research program concerned all the sectors of relevant interest and all levels (plant-tissue-cell-chromosome-gene). Basic directions of the research aimed at the creation of appropriate genetic material, including endurance to biotic and abiotic factors, upgraded quality and optimum productive potential (Hellenic Sugar Industry, 2009).

Moreover, research in seed production and in seed technology aims to provide support in the whole sugar sector and especially the sectors of seed production and seed treatment, by increasing the company's revenue. Mainly the research comprises the following objects:

- Agronomic practice aiming at maximizing the production and optimizing the quality of the produced seed.
- Methodology and evaluation of the seed quality.
- Evaluation of the technical and pelletizing materials and investment practices of the seed (Hellenic Sugar Industry, 2009)

However, nowadays, the stakeholder from the Greek sugar sector stated that R&D activities are not performed or supported due to the bad economic situation the company is in.

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

3.2 Opportunities IBL

3.2.1 Sector related residues

As it was mentioned above, the sugar production is a fairly enough complicated process. Taking into consideration that the cultivated area of sugar beets in Greece amounts to 9,309 hectares (in 2012-2013) (CEFS Sugar Statistics, 2013), the main by-products derived from the sugar process are molasses and beet residues, which are ranged as it is shown below:

- **Molasses**: It contains about 50 % sugar and is used as a substrate for fermentation processes for the production of alcohol, food or feed, citric acid, glutamic acid, amino acids (e.g. lysine) as well as feed additives. 2-4 % of beet production.
- **Sugar-beet pulp pellets**: A portion of the fresh pulp is not available directly for animal feed, but after it is driven for drying. The product resulting from drying is called pastry pie or dry pulp and is an excellent feed. It is marketed as produced or in the form of compressed particles as pellets. 2-4 % of beet production.
- **Fresh pulp**: The product resulting from the "recent beans" of the beets when the sugar which is contained into them has been extracted and called "extracted particles". The "extracted particles" are pressed to remove most of the water and sugar that they contain and the resulting product is called fresh pulp and sold as animal feed. Production depends on demand (Hellenic Sugar Industry).

From data taken from CEFS sugar statistical 2013 report, the annual beet production for the year 2013 amounted to 1,411,840 t. This estimation was made knowing that the annual sugar production was 158,126 t for this year and additionally that a percentage of 11-12 % is referred to the produced sugar. Continuously, it is worth to mention that during the collection process of the sugar beets another main residue derives and can be also estimated in the below table, the beet leaves which can be used as substrate for biogas production. Taking into consideration that the Product/Residue ratio is 2.51 (Apostolakis M., 1987) the produced amount of beet leaves was estimated for the year 2013. From the above, the estimated quantities of by-products are presented in Table 12.


Table 12. Main sugar residues and by-products.

By-products of sugar process production (2013)	
Main sugar residues and by-products	Produced amount, kt/year
Molasses ¹	19.5
Sugar-beet pulp pellets ²	28.2
Fresh pulp ¹	24.8
Beet leaves ³	562.5

¹ Source: (Cefs Sugar Statistics, 2013)

² Estimated amount with the 2% of beet production (Hellenic Sugar Industry, 2009)

³Source: (Apostolakis M., 1987)

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

3.2.2 Potential synergies & benefits

As it is mentioned above, the working months of the sugar industry in Greece is during September-January. Thus, there are many months where the equipment stays idle.

All the above-mentioned by-products, resulting from the production of sugar, cover the needs of industries and cattle-breeders in the internal market. Molasses is used as a raw material to produce alcohol, yeasts and cattle feed. Sugar beet pulp pellets is cattle feed, just like the fresh pulp, and is prepared by dry pulp (by-product of sugar) with the addition of molasses. Nutrica 135 is a sort of cattle feed which is used for fattening the calves and is prepared with dry pulp and molasses, with an addition of trace elements and vitamins.

Figure 9 presents a typical scheme of the sugar process production and the final use of its by-products and wastes.

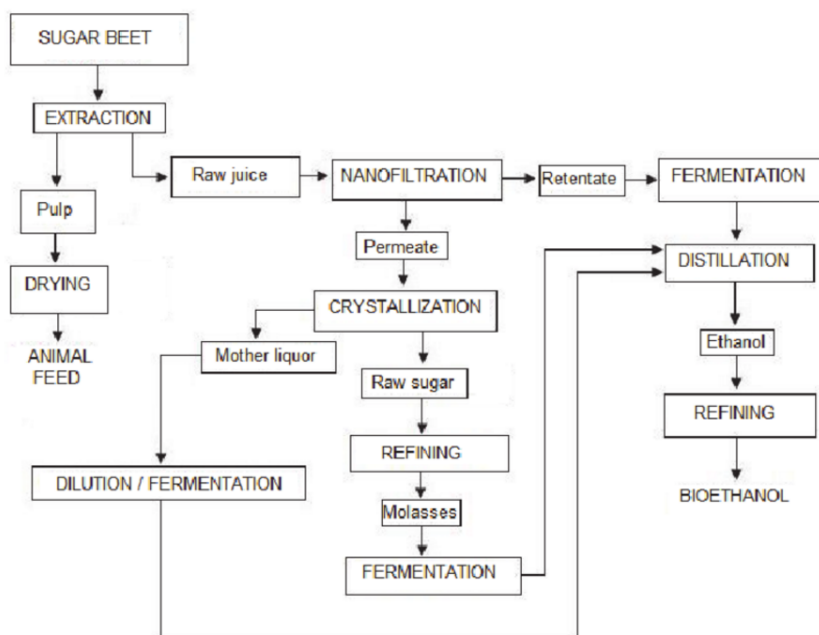



Figure 9. Schematic representation of the sugar production process and the use of its by-products. Source: (Giovanni Di Nicola, 2011)

3.2.3 Market developments

Most of the by-products produced during the sugar production process are already used in the market such as animal feed. It is worth to mention that molasses can be used as a raw material for the production of bioethanol. In Greece, there is no data available that confirms this exploitation.

3.2.4 Non-technical barriers

No specific barriers were arisen for the development of the IBLC concept in the sugar sector in Greece apart from the bad financial state of the sector. The IBLC could probably enhance the sector and push it to new markets and operations.

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18


4 WINE SECTOR

4.1 Profile of the wine sector

4.1.1 Production

The primary feedstock for the wine production is grapes and the end products are wines of different variety. The main steps for the winemaking (which are presented in Figure 10) are the following (Recchia, Daou et al., 2009):

- **Harvest:** The grape clusters are cut from the vineyard and placed in bins or boxes and then transferred to larger containers for transport to the winery.
- **Break:** The grapes are crushed and their stem is extracted at the same time by a crusher consisting of a perforated cylinder with rotating blades.
- **The separation of the juice:** The crushed grapes are placed in a cylinder, and the tube being inflated presses the grapes against the sides of the rotating cylinder and causes the juice to be extracted through the perforations.
- **The processing of must:** White musts are often turbid and it is necessary to settle the suspended particles to separate them.
- **Fermentation:** During this process, the grape juice (sugars present in the must) transforms into an alcoholic beverage.
- **Processing after fermentation:** With suitable composition of the must, yeast type, temperature and other factors, the alcoholic fermentation stops when the available amount of sugar that can be fermented becomes too low.
- **Mineral fermentation:** In malonic lactic fermentation, malic acid degrades into lactic acid and carbon dioxide. Fermentation is caused by enzymes produced by certain lactic acid bacteria.
- **Separation:** Some wines expel part of them very quickly, and the extra wine remains almost shiny. Removal of the waste material during maturation is called separation.
- **Refining:** A process in which a material that helps to separate wine is added. The main processes involved are adsorption, chemical reaction and adsorption and possibly physical motion.
- **Filtration:** The original filters were made up of the rough fabric-covered holes through which the wine was poured.
- **Centrifugation:** Centrifugation, or high speed rotation, used to separate musts, is also applied to wines that are difficult to separate by other means.
- **Cooling:** Temperature reduction often prevents yeast growth and carbon dioxide production, which tends to keep yeast cells inhibited.
- **Exchange:** Another method to stabilize the tartrate is to pass a part of the wine through a device called ion exchanger.

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

- Heating: Pasteurization at 70 to 82 °C can also be used to precipitate proteins, but in modern practice this process is rarely adopted to help in the separation.

Furthermore, in most wineries another process is also followed in order to reuse the main by-products coming out from the winemaking procedure. This process concerns the part of the wine distillery. The feedstock for the distillery process is the grape marc. This is the residue from the pressing of the grapes and the removal of most of the juice destined for the production of wine. As a raw material it is also used for vinegar production and a very small percentage for pure and aromatic wines.

The process of distillery starts with the stirrer and heating of the marc in order to export the distillate. After the marc's heating, the vapors are collected into the distillation vessel where the distillate is separated from undesirable ingredients. Next, the distillate's alcoholic strength is checked by a special system and finally it is directed to the collection tanks. The final distillate' alcoholic strength is 75 % vol. Mixing and dilution tanks follows in order to obtain the required alcoholic strength (40 % vol) and desirable organoleptic characteristics.

Figure 10 below presents the above mentioned steps for the winemaking procedure and Figure 11 shows the main process stages of a wine distillery. More specifically it presents the main distillery process procedure of the Lafazanis winery, one of the biggest winery-distillery in Greece. Most of the Greek wineries include the distillery procedure in order to use all the residues produced by the winemaking process; there are also wineries and distilleries that are operated as separated units.

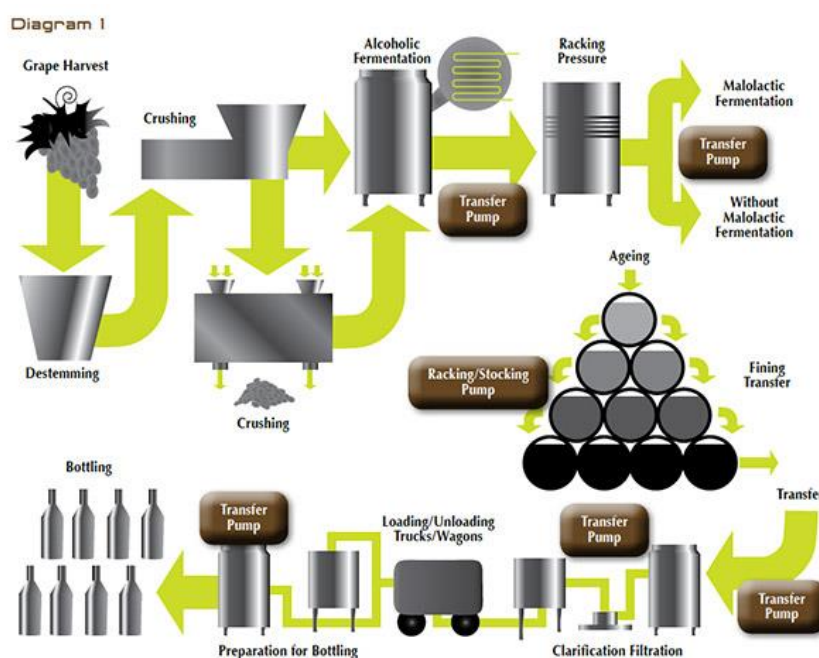


Figure 10. The main stages of the winemaking process. Source: (Food info)

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

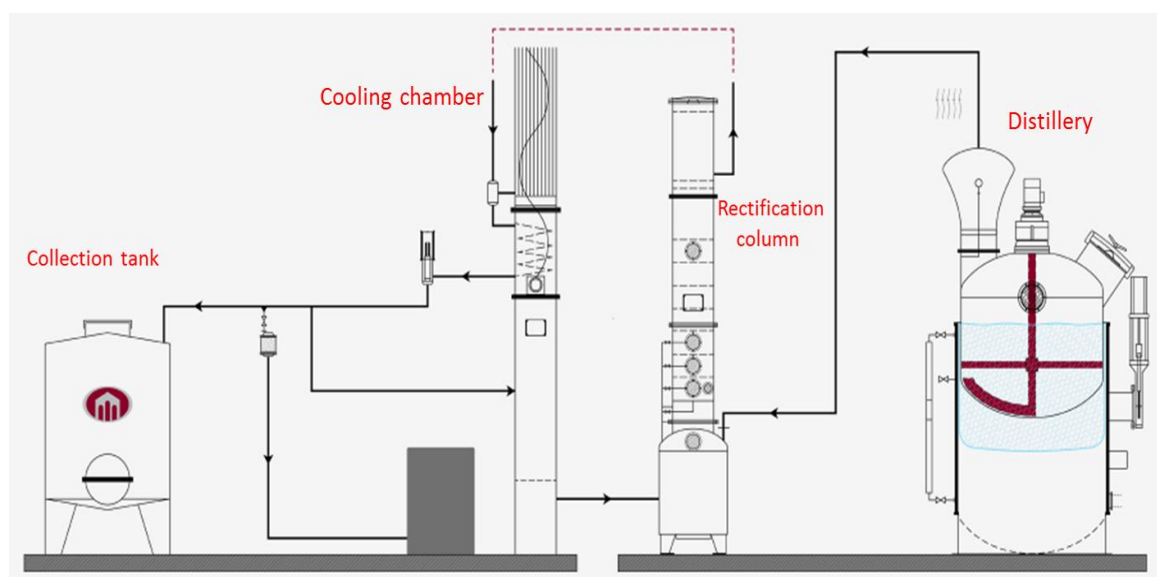


Figure 11. Distillery process. Source: (Lafazanis winery)

4.1.2 Volume of the sector

The wine sector in Greece, as director of KEOSOE (Central Cooperative Union of Wine Products) stated, is estimated to consist of 1,100 wineries, 40 cooperatives and around 100 distilleries producing more than 7,000 labels. Greece produces 34 PDO (Protected Destination of Origin) labels and 120 PGI (Protected Geographical Indication) labels. According to the statistical data from the Ministry of Agriculture the total wine volume for the wine-growing period of 2015-2016 was 2,458,421 hl of wine, from which 745,809 hl were red wine and the rest 1,712,612 hl were white wines. Moreover, in order to understand the volume of this sector, Table 13 presents the total wine production in accordance with the total vine cultivated area in Greece.

Table 13. Annual wine production from 2011 to 2016. Source: (KEOSOE)

Wine production from 2011 to 2016					
	2011/2012	2012/2013	2013/2014	2014/2015	2015/2016
Total cultivated area (ha)	66,473	65,330	65,020	64,048	62,723
Total wine production (1,000 hl)	2,660	3,050	3,268	2,750	2,458

Figure 12 shows a clearer picture about the wine production in Greece. The most productive region in Greece is Peloponnese with a percentage of 29.30 % of domestic wine production and then follows Attica and Central Greece with a percentage of 20.16 % of the domestic wine production.


	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18



Figure 12. Percentage distribution of the wine production in Greece. Source: (KEOSOE)

Additionally, regarding the distribution of the cultivated wine grapes varieties by region, the next thematic map (Figure 13) illustrates the areas with the most important wine grape variety by region and their percentage contribution to the total produced wine of the region (ELSTAT, 2015).

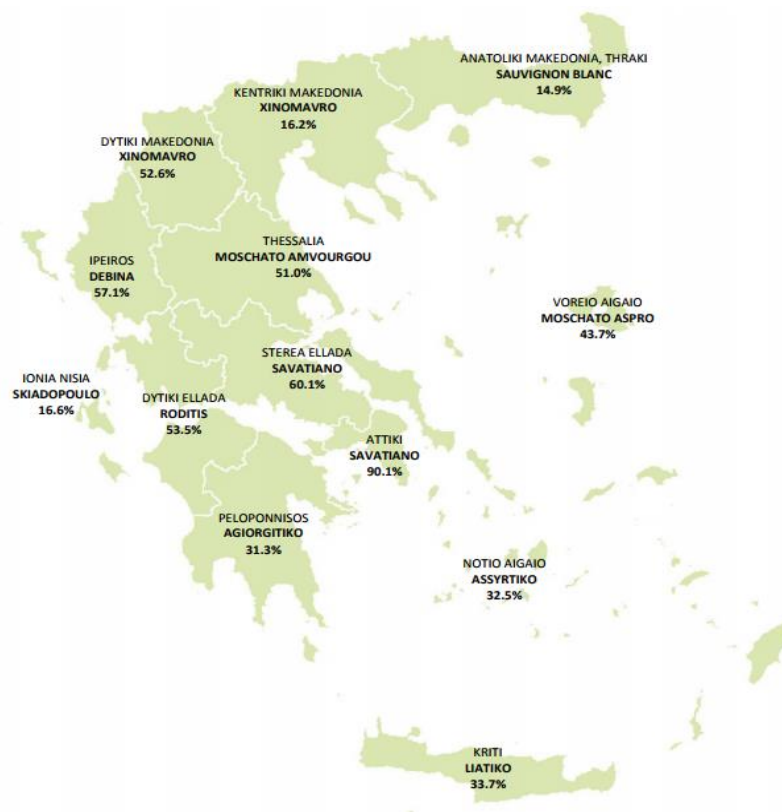



Figure 13. Main wine grape variety by region. Source: (ELSTAT, 2015).

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

4.1.3 State of the sector

The wine sector in Greece has a significant role in the economy of Greece. Apart from the employment positions that it offers, the wine sector has one of the highest turnovers in agro-industries. Table 14 presents an overview of the annual turnover of wine sector during the last years, 2011-2014 (inr.gr, 2014). For 2017, the annual turnover of wine sector was estimated at 380 M€ (personal communication, KEOSOE, 2017)

Table 14. Annual Turnover of Wine Sector in Greece. Source: (inr.gr, 2014)

Annual Turnover of Wine Sector in Greece				
	2011	2012	2013	2014
Turnover (M€)	200	197	180	181

Moreover, the Greek wine sector has significant imports and exports. For example, in 2015-2016 the imports of wine were rising at 208,952 hl with a value of 33 M€ and the exports were rising at 301,253hl, with a value of 74 M€.

Table 15 presents the main wineries based on their annual sales for year 2014.


Table 15. Economic size of the biggest Wineries in Greece. Source: (inr.gr, 2014)

Economic Size Of The Biggest Wine Companies In Greece				
NAME	LOCATION	TOTAL ASSETS (M€)	SALES (M€)	EBITDA (M€)
TSADALIS S.A.	Chalkidiki	83	31	4
GREEK WINE CELLARS- KOURTAKIS S.A.	Markopoulo	34	26	0,8
CAVINO	Aigio	22	17	0,9
BOUTARI S.A.	Naoussa, Crete, Santorini, Kilkis	46	12	-0,1
KOUTSODIMOS S.A.	Nemea	5	6	0,6
TSAKTSARLIS- GEROVASILEIOU S.A. (VIVLIA CHORA)	Kavala	11	6	1
LAZARIDI S.A.	Drama	36	6	0,5

4.1.4 Typical size of the companies

The total annual production capacity of a typical winery in Greece reaches 4,000 t of wine per year (Lafazanis winery). Although, it is worth to mention that the total annual production capacity of the biggest winery in Greece is 20 thousand hl (in wine and spirits).

Moreover, according to the feedback from the stakeholders the amount of permanent workers that are employed in the whole wine sector are around 24,300 employees.

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

4.1.5 Distinctive facilities of the sector.

The facilities that are used in this sector are in full operation during the months from October to February. The rest of the year, the facilities operate for the marketing of the wines (packaging, bottling and trade). Unfortunately, due to the complexity of wine production process these facilities cannot be used for every other procedure. Perhaps, the centrifugators and the distillation equipment that are used in the distillery process can also be used in other industries whose final products are distillates like beer or other alcoholic industries. Furthermore, the storage facilities that are used in this sector can possibly store other material during idle months for the wineries.

4.1.6 Degree of innovation

Unfortunately, the stakeholder from the Greek wine sector stated that during the last years, due to the economic crisis, there is no currently interest for innovation/ R&D actions. He stated that most facilities in the wine sector do not operate with the state of the art machinery but they are trying to catch up with the latest developed technologies.


However, large wineries in Greece use the latest/ state of the art technologies for the production of wine. A minority of wineries have some R&D activities. For example, one of the biggest winery in Greece (Lafazanis) develops a new innovative technique in the field (precision agriculture), in order to maximize the productivity of grapes, by means of biological cultivation.

4.2 Opportunities IBLC

4.2.1 Sector related residues

The main solid by-products and residues produced in modern winery industries include: the grape pomace (marc), the grape stalk, the wine lees and the winery wastewater (vinasse). Moreover, the main by-products coming from the grape pomace are: the seeds and the skins left after the crushing, draining and pressing stages of wine production. Grape marc is commonly processed to produce alcohol and tartaric acid, which results in a new lignocellulosic by-product, spent grape marc. The wine lees are accumulated in the bottom of grape juice or wine fermentation tanks. The distillation of the alcohol from low-quality wine, wine lees and grape marc produces a large quantity of a viscous and acidic wastewater known as vinasse. In many wineries, an aerobic depuration process is operated after the distillation to treat the winery effluents such as vinasse and winery wastewater, therefore, generating waste biosolids. A large proportion of the wastewater comes from cleaning and cooling processes (Poonam Singh nee' Nigam, 2009).

Wine cellars by-products (such as the dried grape marc, lees and vinasses) and residues (such as the grape stalks) can be used for energy purposes. Figure 14 presents an estimation for the amounts and compounds of the most generated (in terms of amount of kg) by-product in winemaking.

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

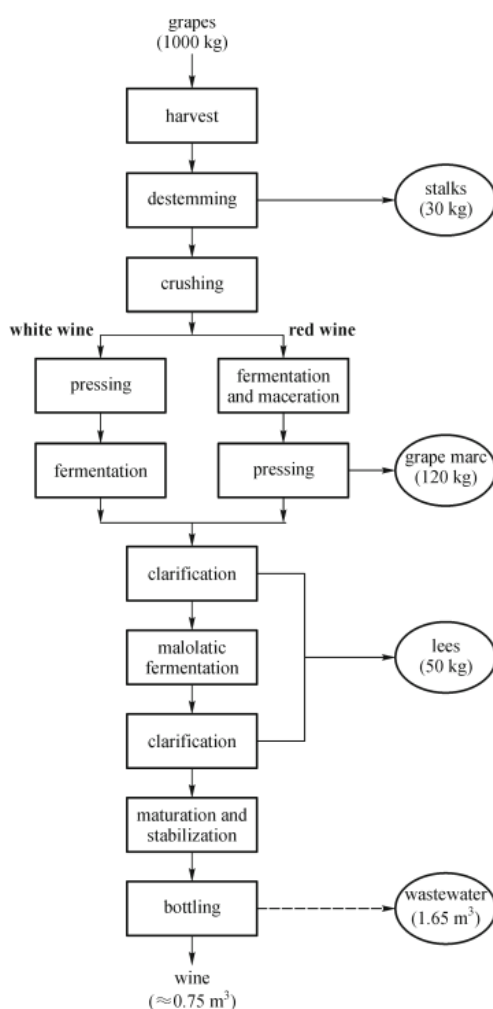



Figure 14. Winemaking by-products. Source: (Oliveira, 2014)

According to these estimations (from Figure 14) and assuming that 1 liter of wine corresponds to 1.2 kg of grapes, the estimated by-products of the wine sector are presented in Table 16.

Table 16. Greek primary wine industry by-product estimation for 2015-2016.

Greek wine industry by-product estimation (2015-2016)	
Material	kt/ year
Grape for wine production	295
By-products	kt/ year or Ml/year
Wine	245.8
Stalks (kt/year)	8.8
Grape marc (kt/year)	35.4
Lees (kt/year)	14.7
Wastewater (Ml/year)	487

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

Another main residue that derives from the wine sector is that of vine prunings. Vine prunings, as in the case of olive prunings, are not exploited. When pruning is performed, the most common practices followed for these residues is burning them in open fires, which contributes negatively to the environment, and mulching of this biomass in order to incorporate it into the soil as fertilizer. However, these residues can be exploited in different ways, mainly in the energy sector.

As in the case of olive prunings, there are no recent national surveys based on field data regarding the availability of vine prunings in Greece. Like in the olive sector, three methods estimate the potential of vine prunings. The methods are described in paragraph 2.2.1 “Sector related residues” of olive oil sector. The moisture considered in all methods is 40 % wt for vine prunings. The vine pruning potential is presented in Table 17 based on these methods.

Table 17. Potentials (kt of dry matter per year) for vine prunings in Greece according to several data sources.

Potentials for olive prunings (kt of dry matter per year)			
Source	Reference Year	Methodology	Vine Prunings
Apostolakis et al.	1980	RPR + national production statistics	566
Biomassud Plus	2014	- // -	398
S2Biom	2020	RSR + CAPRI surface projections	93


From the three methods, the national annual pruning potential is estimated in a range of 93-566 dry kt. Finally, in the framework of uP_running project (Grant Agreement No 691748) on-field measurements of vine pruning production were performed in several vineyards around Greece. Based on these on-field measurements, S2Biom’s RSR values are more in line with the RSR values found from the on-field measurements for vine prunings.

4.2.2 Potential synergies & benefits

In the wine sector, several papers present the potential of using wastes from wine distilleries for the production of energy and biobased products.

Zacharof (Zacharof, 2016) investigated the valorization of winery wastes and their exploitation as feedstock to produce platform chemicals, biofuels, and energy. The paper proposes schemes to be applied in wineries at industrial scale in order to further use the wastes that are generated.

Both the solid and the liquid winery wastes can be used successfully as feedstock for the production of high value chemicals. This can be achieved either in a conventional chemical-biochemical biorefinery (wine lees, vinasses, grape marc) (Figure 15) or in green biorefinery (leafs, grape pomace) (Figure 16) or in a lignocellulosic biorefinery (stalks, peels, seeds, trimming vine shots, pips, pomace) (Figure 17).

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

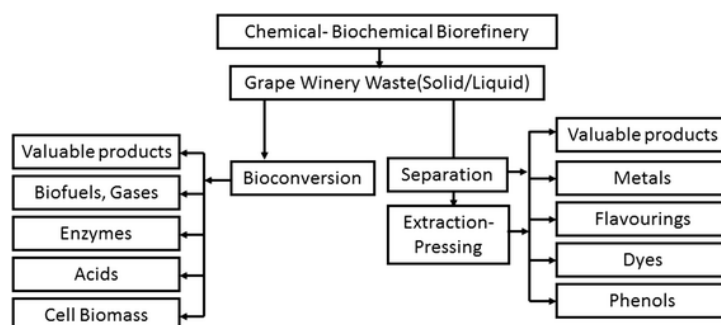


Figure 15. The chemical-biochemical biorefinery assortment applied to winery waste. Source: (Zacharof, 2016)

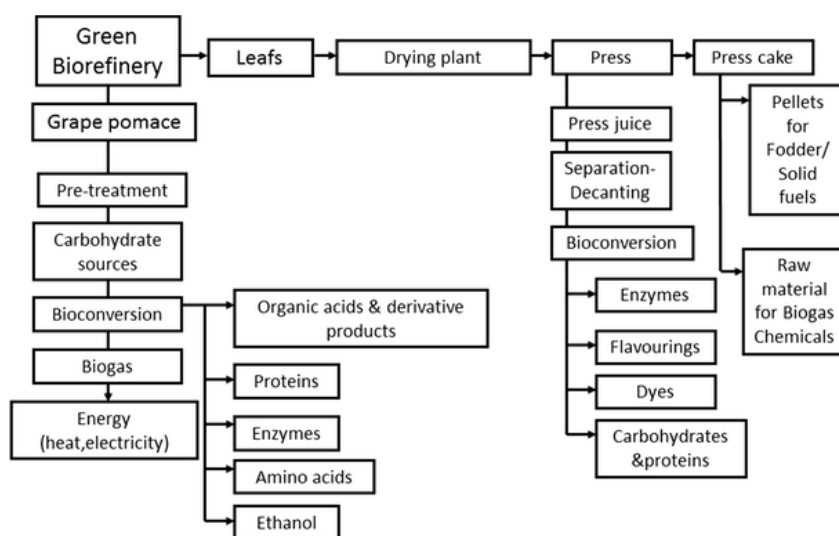


Figure 16. The green biorefinery assortment applied to winery waste. Source: (Zacharof, 2016)

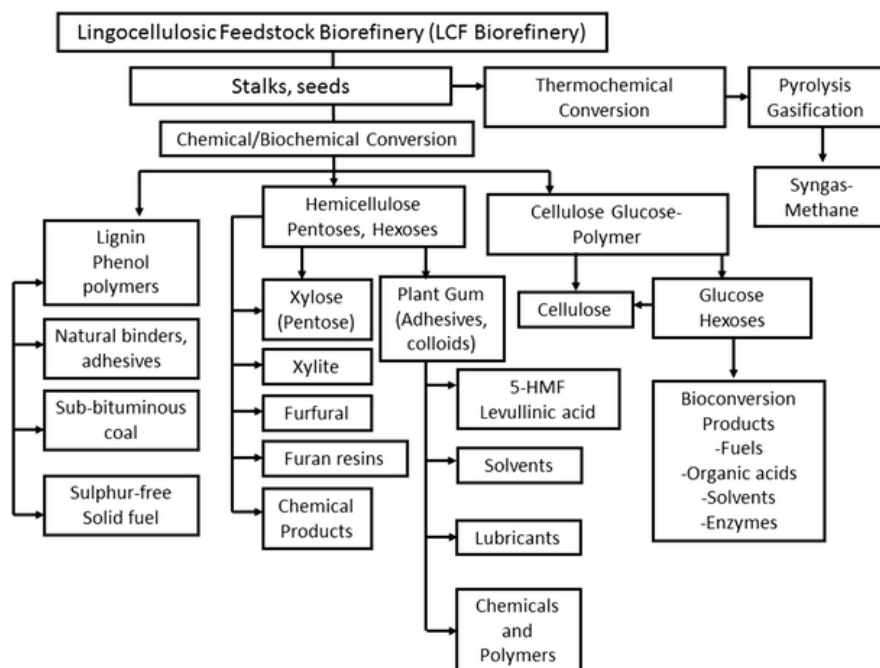



Figure 17. The Lignocellulosic Feedstock (LCF) Biorefinery assortment applied to winery waste. Source: (Zacharof, 2016)

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

4.2.3 Market developments

The winery residues (wine lees, grape marc, vinasses and wine leaves) can be used as feedstock to produce platform chemicals such as lactic acid, extract polyphenols (e.g. resveratrol) to be used in cosmetics, biofuels including ethanol, enzymes, chemical intermediates, and energy through pyrolysis and anaerobic digestion.


From the communication with the stakeholder of the Greek wine sector, he stated that from the wineries residues, the grape marc is currently used in the market as fertilizer. It is not eligible for the production of animal feed due to the odor.

Furthermore, there are several ways to exploit the wastes from wineries. For example, an Australian company Australian Tartaric Products (ATP, 2015) collects wastes from local wineries, distills them to make grape spirit and extract tartaric acid which is used again in the wine industry. Continuously, the company generates steam by burning the grape wastes in a biomass boiler and sells the excess of electricity generated, after covering its own power consumptions.

In addition, the vine prunings can be used in order to produce pellets or chips for solid biofuels market or they can be used directly as feedstock for power and/or heat plants. Such is the case of Pelets de la Mancha. This company, which is located near the town of Socuéllamos in Spain, manufactures solid bio-fuels in pellet and chip exclusively form from vineyard prunings and sell its products either to public or private companies which use pellet for heating purposes as well as industrials units, or to large companies that produce power from biomass. Moreover, the pellets can be used in buildings with a high heating demand (where medium sized boilers above 200 kW can be installed) and the chips can be used for heating use and industrial use in small/medium/large enterprises (uP_running). Additionally, another recorded case is according to Corona & Nicole (Corona et al., 2010), Settesoli -a huge winery in Italy- which decided to construct a biomass energy plant of 1 MWe that would use as feedstock the vine canes from pruning, along with pomaces and wastes from the winemaking process.

4.2.4 Non-technical barriers

No specific barriers were found regarding the implementation of the IBLC concept to the wine sector apart from the fact that economic crisis has made most of the companies turn into themselves, unable to invest or be “open” to new innovative ideas or investments. Another main barrier is the lack of knowledge of the sector’s stakeholders on the exploitation of agro-residues.

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

5 GRAIN CHAIN


5.1 Profile of the grain sector

5.1.1 Production

The most important grains that are cultivated in Greece are wheat, both soft and durum, barley, oats, rye and maize (grown alone and grown with beans and other crops). Cereals are the most important category of plants grown for human nutrition. From cereals one of the basic types of human food, bread, is produced as well as raw materials for the food industry, fodder, etc.

The production process, that follows the harvest of wheat, has the following stages and it is presented in Figure 18 (Greek Flour Millers Association):

1. **Receipt and storage** - The wheat is received from ships and trucks. Cereals undergo meticulous sample checking, in order to verify the quality of the product. Upon unloading, the wheat is weighed and is subjected to an initial mechanical cleaning to remove impurities.
2. **Cleaning** - Before being milled, the wheat must be fully cleaned from any impurities and wetted to the desired level for milling. The impurities that may be present in wheat are: grains of other cereals, straw, paper, stones, sand, dust, glass, metal. Impurities are separated from the wheat mechanically based on:
 - Size
 - Shape
 - Specific gravity
 - Magnetism
3. **Wetting** - The wheat's moisture content must be kept at certain levels in order to achieve the best possible separation of the flour from the bran. The amount of added moisture and the residence time of the wheat before milling depends on its hardness, climatic conditions and the moisture specifications of the finished product. The wetting of wheat allows a more efficient separation of bran from the endosperm and the appropriate degree of softness of the interior grain to achieve good performance during milling.
4. **Milling** - The milling process aims to remove the endosperm (flour) from the bark (bran) of wheat. This is accomplished through a gradual milling process, carried out with the help of rollers and consisting of three steps:
 - The breaking system (which separates and removes the endosperm from the bran in relatively large pieces).
 - The scraping system (which removes small pieces of bran and germ, which are attached to the endosperm).
 - The reduction system (which mills the endosperm into flour).
5. **Mixing** - Mixing allows the creation of a large number of products, homogenising different flour and auxiliary materials at the desired ratio.

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

6. **Special Processing** - Special processing consists of:

- Drying
- Separation of proteins
- Heat treatment of bran and milling fractions

7. **Storage and Packaging** - The flour created by milling is transferred into storage silos. From there, the flour will be taken to a control screen, a packaging device, a metal detector and finally a palletising device.

8. **Quality Control** - The quality control of the flour begins with the control of the received wheat, continues in the various stages of milling and ends with the control of the final product. The quality control ensures that the flour has the best qualities, while also performing tests to verify that the grains are free of harmful toxins, pesticides or other harmful microorganisms.

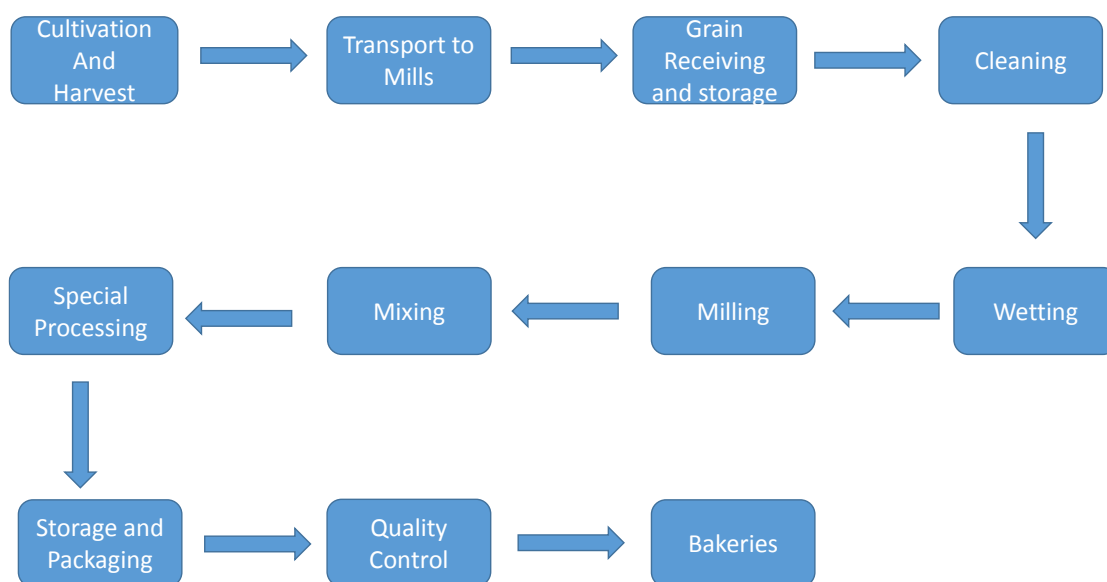


Figure 18. Overview of the grain production process. Source: (Greek Flour Millers Association)

5.1.2 Volume of the sector

According to the annual cereal balance for the production period 2015/2016, the total amount of the cereal production in Greece was 3,183,756 t in a cultivated area of 926,965 hectares. In Table 18 the cereal balance is presented for the economic year 2015/2016.


	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

Table 18. Production of Grain in Greece. Source: (Ministry of Agriculture, 2016).

Cereal Balance 2015/2016					
	Initial stocks (t)	Using production (t)	Area (ha)	Yield (t/ha)	Human consumption
Soft wheat	80,000	352,975	154,843	2.28	615,000
Durum wheat	80,000	785,657	332,525	2.36	671,000
Barley	6,000	353,886	154,112	2.30	5,000
Maize	170,000	1,542,304	152,047	10.14	5,000
Rye	2,500	22,974	15,715	1.46	3,000
Sorghum	800	10,274	2,861	3.59	100
Oats	5,000	83,058	96,013	0.87	500
Triticale	2,500	31,989	18,888	1.69	200
Rest	1,500	639	234	2.73	300
Total cereal	348,300	3,183,756	926,965	3.43	1,300,100

5.1.3 State of the sector

Grain chain consists one of the most important sector in Greek economy with serious imports as well as exports quantities as it can be seen in the Table 19.

Table 19. Total imports and exports of grain chain in Greece. Source: (Ministry of Agriculture, 2016).

Grain Chain Imports/ Exports 2015/2016		
	Total imports (t)	Total Exports (t)
Soft wheat	907,773	11,607
Durum wheat	181,248	205,528
Barley	105,715	748
Maize	484,123	25,685
Rye	1,349	71
Sorghum	552	21
Oats	10,328	48
Triticale	84	28
Rest	15,183	80
Total cereal	1,706,355	243,817

Moreover, Table 20 presents an overview of the annual turnover of grain sector during the last years (2011-2014).


	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

Table 20. Annual Turnover of Grain Sector in Greece (2011-2014). Source (inr, 2014)

Annual Turnover of Grain Sector in Greece				
	2011	2012	2013	2014
Turnover (k€)	400,045	382,868	361,099	343,164

As it can be seen from the annual turnovers, the grain sector in Greece has a decline during the last years due to the low profit margins and the economic crisis. Several grain mills operate in Greece. The largest mill according to the information gathered from the stakeholder as well as from the table below, is the LOULIS MILLS SA., with a market share of 25 %. After that, about 10 more companies follows with a total market share of 40 %. Around 100 smaller companies are also operating in the sector, the majority of which is facing serious economic problems. Table 21 presents the main grain mills based on their annual sales for year 2014.


Table 21. Economic size of the biggest Grain mills in Greece. Source: (inr.gr, 2014).

Economic Size of the main Mills In Greece				
NAME	LOCATION	TOTAL ASSETS (k€)	SALES (k€)	EBITDA (k€)
LOULIS MILLS S.A.	Thessaloniki, Kavala, Volos	161,303	88,006	9,589
PAPAFILI MILLS S.A.	Korinthos	44,054	39,565	3,212
KEPENOS MILLS S.A.	Patra	36,715	35,865	3,300
MILLS OF CRETE S.A.	Chania, Crete	77,666	35,533	2,446
MILLS THRAKIS S.A.	Evros	35,123	34,360	2,201

5.1.4 Typical size of the companies

Currently, grain chain sector in Greece consists of few large and high-tech industries, small amount of medium scale industries and a large number of small-family scale industries with low capacity and older equipment. Today, flour mills and industries in Greece that produce and trade flour account to 800 approximately (personal communication, AIXMEAS, 2018). These industries can be divided based on their capacity in:

- Units with production capacity over 500 t of grain grinding per day. Such industries are “AGIOU GEORGIU MILLS” and “LOULIS MILLS SA”. The large industries of the sector are equipped with the latest technology machines. These industries have specialized personnel, labs for quality assurance of raw material and products and appropriate storage sites for the products.
- Units with capacity between 100-200 t per day such as “GIANNITSON MILLS SA.” and AGIOU DIMITRIOU MILLS SA”.
- Units with capacity lower than 100 t per day. Under this group a large number of family businesses are included that usually have low productivity and satisfy local markets.

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

According to stakeholder feedback, around 3,000 permanent and seasonal employees, apart from the grain farmers, can be found in the whole grain chain sector.

5.1.5 Distinctive facilities of the sector

Unfortunately, the grain facilities are in full operation during the whole year, usually this refers to large companies of the sector, and as a result all the equipment is used for the production purposes. However, most of the grain chain sector companies possess numerous storage silos, in order to store the annual cereal production for their clients. These silos can be used for storing different kind of products when they are low on cereals.

5.1.6 Degree of innovation

According to the agronomist of the LOULIS MILLS SA., the large companies of this sector invest into innovative ideas considering the waste management of their residues or the use of them into renewable energy. Indicatively, LOULIS MILLS SA does not appear to have any residue during the whole year as they manage and exploit them for their energy purposes (e.g. for heating purposes during the procedure process of their main products).

Furthermore, companies in the grain sector invest in technologies in order to be able to produce “functional” products, meaning products with better quality, with no diseases, without gluten etc.

5.2 Opportunities IBL

5.2.1 Sector related residues

The primary biomass residue, which is produced by the cereal production, is mostly straw with smaller biomass components such as chaffs. Usually producers leave the straw on the field with the aim to incorporate it into the soil as a natural fertilizer or they collect it in order to use it for livestock bedding. This biomass is identified as having most potential when used for ethanol production.

Residues are also derived from the industrial processing (milling and grinding) of the cereals. Today, the majority of these residues is used in animal fodder. A typical cereal flour plant in Greece produces almost 50,000 t of by-products each year and sell them either in bulk form or in packages as animal feed.

However, the evaluation of the quantities and geographical distribution of this category of residue is complicated because of the different processing technologies, the size and location of the processing plants and the characteristics of the final products. Furthermore, there is no official data on the production of agro-industrial products at regional level in Greece that could facilitate the estimation of the residues produced. Therefore, it is necessary to follow different methodologies, according to the availability of data for each type of residue. For this reason, in order to estimate the cereal residues quantities for the economic year 2015/2016, above mentioned amounts of cereals and the product/residue ratio which is found in literature (OECD, 2004), are used. The calculated quantities of the cereal residues, deriving from grain crops, are shown in Table 22.

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

Table 22. Grain crop residues studied for Greece sector.

Cereal Residues Quantities for the economic year 2015/2016					
	Moisture (%) ¹	Production (t) ²	Product/Residue ratio ¹	Residues (t)	Type of residues
Soft wheat	15	352,975	1.00	352,975	straw
Durum wheat	15	785,657	1.00	785,657	straw
Barley	15	353,886	1.24	285,392	straw
Maize	60	1,542,304	1.42	1,086,130	stalks
	50		3.75	411,281	cobs
Oats	15	83,058	1.27	65,400	straw

¹ Source: (OECD, 2004)

² Source: (Ministry of Agriculture, 2016).


5.2.2 Potential synergies & benefits

Mainly the straws produced as residues from cereals can find various applications. Straws can be used as raw material for energy purposes such as pellets or for the production of bio-chemicals and biofuels. Unfortunately, the existing facilities cannot cover the needs for the exploitation of this biomass. New technologies should be adopted in order for the grain mills to be able to process the generated residues.

5.2.3 Market developments

Cereals, are a major source of agricultural waste in many countries. As it was mentioned above the most common residue of the grain chain sector, straw, can be utilized as raw material in order to attain bio-energy markets through the production of solid bio-fuels (in the shape of pellets perhaps) or by directly using it. These agro-residues can be exploited in energy plants with the aim to produce energy from the straw combustion. This idea could open new roads in the bio-energy markets but so far it consists difficult the start –up of this business line (especially in Greece) due to the difficult economy situation as well as to the prices variability of this sector.

However, grain chain residues can be used for cattle feed, fertilizers as well as in compost production and this leads to the development of new markets. Already, these operations are followed in some countries (e.g. Vietnam) but due to the low finance sources, there are problems regarding the waste management. Nevertheless, it is worth to show a typical scheme of the available exploitation paths of grain residues that could be the pioneer for a new market business line in the existing agro-industries.

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

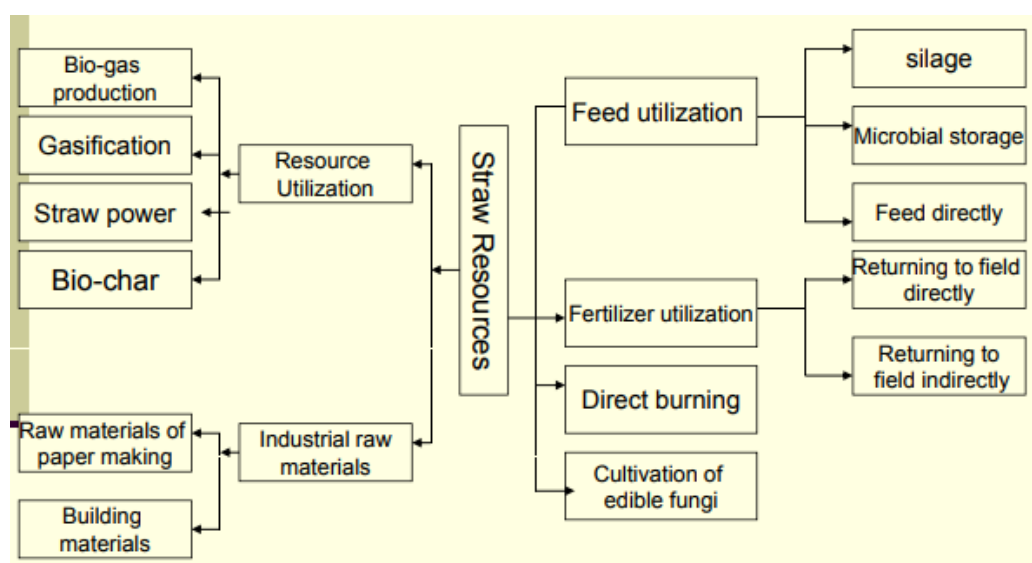



Figure 19. Typical management practice model of straw utilization. Source: (Dang Khanh, 2010)

5.2.4 Non-technical barriers

The main barrier, according to the interviewed stakeholder, is that eventually there are no idle times for the available equipment and the amount of by-products produced are totally consumed either as animal feed or for energy purposes.

Another barrier, mentioned by the sector's stakeholder (personal communication, AIXMEAS, 2018) is that it would be difficult for the farmers to give their agricultural residues (e.g. straw) to the IBLC as they incorporate them on their fields, giving organic matter to the soil. Thus, the farmer needs something else to replace the agro-residue and give the organic matter to his soil. As a result, the stakeholder stated that in order for the exploitation of agro-residues in the grain chain to be feasible, a synergy must be established between the grain farmers and the IBLC or end user. The farmers will have to take something in exchange of the agro-residues (straws), for example some money, in order to buy bacteria or the appropriate material to increase the organic matter of his soil.

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

6 VEGETABLE OIL EXTRACTION

6.1 Profile of the vegetable oil extraction sector

6.1.1 Production

There are several vegetable oil extraction industries in Greece. Vegetable oil is extracted from various primary feedstock like cotton seeds, soya, sunflower, etc. Apart from vegetable oils, other products derive from these crops like seeds and fats that are used in animal feed. Vegetable oil is used either for edible use or for the production of bio-diesel.

One of the main companies in the vegetable oil extraction sector in Greece is SOYA Mills with several units across Greece. SOYA Mills produces and exports seed oils such as sunflower oil, soybean oil, rapeseed oil and proteins derived from processing oilseeds. In its main processing unit there are two modern processing units which undergo the following procedures:

- **Oilseed Processing Unit:** Oilseeds (such as soybeans, rapeseeds, sunflower beans) are crushed to produce edible oil and protein meal. Incoming oilseeds, received by vessels, are transported to silos for storage. From there, they are forwarded to the pre-treatment plant. The process begins by cleaning the seeds to remove impurities. Next, they are cracked and dried, before they are formed into flakes, which are to be pressed crushed at the next stage. The cake produced is then subjected to an extraction process in order to remove any remaining oil. Before its storage, the protein meal is passed through a process of improving its nutritional value and digestibility. The other product resulting from the aforementioned treatment is crude vegetable oil.
- **Crude Vegetable Oil Processing Unit:** In order for crude oils to become edible, they ought to undergo a multi-stage process: Degumming, refining, bleaching and deodorization. In degumming, phosphatides (lecithin) are being removed by means of centrifugation. The refining process removes free fatty acids from the oil. Bleaching removes the pigments and various other impurities oil. Finally, the deodorization process removes volatiles through a distillation column.

The main overview of SOYA Mills processing procedures is presented in Figure 20 and the main stages that are followed during the vegetable oil extraction process are shown in Figure 21.

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

Table 23. Production of Seed plants in Greece, 2014. Source: (ELSTAT, 2014).

Seed production in Greece, 2014			
	Production (t)	Cultivated areas (ha)	Oil content (%)
Seed Cotton	820,275	276,194	15-25
Sesame	187	184	50-60
Sunflower	192,227	76,381	35-52
Sorghum Broom Seed	371	76	-
	101		
Groundnuts	2,693	757	25-30
Sugar beets	455,973	7,127	
Soya Seed	7,846	2,809	18-24
Rapeseed	8,173	4,623	30-50
Maize	1,861,149	167,364	3
Total	3,348,995	535,515	-

Moreover, the production of vegetable oils in Greece from different seeds is presented in Table 24 (Fediol, 2016) for the years 2014, 2015, 2016. The vegetable oil production in Greece these years remains almost stable.

Table 24. Production of Vegetable oils in Greece for 2014-2016. Source: (Fediol, 2016)

Vegetable oil Production, 2014-2016			
	2014 (kt)	2015 (kt)	2016 (kt)
Groundnut	4	4	4
Soya	50	50	61
Rape	9	7	7
Sunflower	45	48	38
Cotton	24	19	21
Maize germ	-	14	5
Total	132	143	136

Furthermore, there are 3 large scale vegetable oil extraction industries in Greece as well as a few industries of smaller scale (personal communication, NUTRIA, 2017).

6.1.3 State of the sector

The vegetable oil sector in Greece is relatively small compared to other EU countries. According to the production, imports, exports and consumption of vegetable oils (Table 25) the shape of the sector can be characterized stable as no major growth or decline appears in the latest years.


	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

Table 25. Imports/ Exports and consumption of Vegetable oils in Greece. Source: (Fediol, 2016).

Vegetable oil Imports, Exports, Consumption in Greece			
	2014 (kt)	2015 (kt)	2016 (kt)
Imports	242	239	232
Exports	29	30	26
Domestic Consumption	345	353	342

In Table 26, the economic data of the most important vegetable oil production and standardization companies are concentrated. SOYA MILLS as well as SOYA ELLAS has the leading role in the Greek vegetable oil economy.

Table 26. Economic size of the most important Vegetable oil extraction and standardization companies in Greece. Source: (inr, 2014).

Economic Size of the main Vegetable oil extraction companies In Greece, 2014				
Company Name	Location	Total Assets (k€)	Sales (k€)	EBITDA (k€)
SOYA ELLAS	Evia	104,465	233,320	12,969
SOYA MILLS S.A.	Korinthos	120,587	210,276	11,733
PETTAS N.P.	Patra	11,649	126,619	12,355
MINERVA S.A.	Viotia	70,265	75,798	2,757
AGROINVEST	Fthiotida	118,929	92,096	9,181
XAIOTOGLOU	Thessaloniki	177,732	83,791	10,174
EGNATIA S.A.	Evros	5,473	2,928	154

6.1.4 Typical size of the companies

A typical Greek company that produces cotton oil is KAFANTARIS- PAPAKOSTAS S.A. Ginning & Oil Mills. They produce refined, bleached, deodorized cotton seed oil. The process they follow is by refining, bleaching and deodorizing neutral cotton seed oil. Neutral cotton seed oil is produced by pressing of cotton seeds. The annual production of the company is 2,000 t of seed oil.

A typical vegetable oil refinery can operate 300-400 t of seeds/ day (personal communication, NUTRIA, 2018).

6.1.5 Distinctive facilities of the sector

Vegetable oil industries mainly operate from September to April. The operation of the facilities depends on the feedstock these facilities use. For example, facilities that operate with sunflower, operate from September to April as mentioned above. However, facilities that use soya as feedstock, which is imported mainly in all periods, operate all year (personal communication, NUTRIA, 2018).

Some facilities of this sector can be also utilized for other purposes. Because of the similarities that are noticed among the vegetable oil extraction sector and olive oil sector, during the crushing and

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

centrifugation processes, equipment can be used for both purposes with modifications. Moreover, storage facilities can be used from the feed and fodder sector as the main by-products from this sector are intended for animal feed.

6.1.6 Degree of innovation

The vegetable oil extraction units use a simple technology, compared to other sectors such as pomace mills in olive sector. No special R&D activities have been performed on the vegetable oil sector in Greece.

6.2 Opportunities IBL

6.2.1 Sector related residues

Oilseeds are supplied by agricultural producers and then crushed and processed into seed oils and vegetable proteins. In most cases, oilseeds can find various applications and especially as feedstock for renewable fuels. The primary use of vegetable proteins is that of animal feed. Vegetable oil is the main product derived by the processing of oilseeds and it can be used in animal feed industries, in chemical industries as well as for human's nutrition. The most important vegetable oils are soybean oil, sunflower oil, corn oil, rapeseed oil and palm oil. As we can see from the Table 27, the most valuable vegetable oil cultivations in Greece are the sunflower and the soya as they have the highest content of vegetable oil compared to all the other similar cultivations. Indicatively sunflower contains around 40 % of oil while soya 20 % of oil. After these two cultivations, cotton is followed with a content of oil around 20 % of the cotton seed. Due to the high cotton production in Greece, which is the highest in Europe (European Commission, 2017), the quantities of residues deriving from cotton cultivation are high compared to other residues. Currently, cotton-ginning residues are used as fuel in the cotton ginning plants for steam production for various internal uses (drying of cotton, wetting of lint, treatment of cottons seeds, etc.).

Table 27 presents the estimated residues of vegetable oil extraction regarding year 2016. The residues were estimated considering how much oil was produced from each seed specie and by knowing how much seed was crushed.

Table 27. Estimated Oilseeds Residues Quantities for 2016. Source: (Fediol, 2016).

Estimated Oilseeds Residues Quantities for 2016		
	Crushed oilseeds (kt)	Seed residues (kt)
Groundnut	10	6
Soya	329	268
Rape	16	7
Sunflower	86	48
Cotton	137	116
Maize germ	10	5

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

Furthermore, it is worth to mention that apart from the residues generated from seed crushing, there are also residues generated during the harvesting of seeds from the crops. These residues are agro-residues like straws, stalks etc. that can be exploited for energy or fuel use. Table 28 presents the estimated agro-residues generated from all the fields containing the corresponding crop used for the vegetable oil extraction in Greece. As a result, the table presents the potential of agro-residues of all the crops, not only the crops used for vegetable oil extraction but also for other sectors (e.g. grain-chain). The following quantities are estimated taking into consideration the RPR ratio and the seed crop production for 2014, as mentioned on Table 23.

Table 28. Estimated Field Residues Quantities for vegetable oil crops in Greece for 2014. Source: (Stephanie Searle, 2013)

Estimated Field Residues Quantities for Vegetable oil crops, 2014				
	Moisture (%)	Seed production (kt)	Residue to Product Ratio (RPR)	Field Residues (kt)
Groundnut ¹	15	2.7	2.5	7
Soya ²	15	7.8	2.5	20
Rape ²	15	8.2	1.08	9
Sunflower straw ³	40	192.2	2	384
Cotton stalks ³	45	820.3	2	1,641
Maize stalks ³	60	1,861.2	0.7	1,303

¹ Source: (Gunther et al., 2007)

² Source: (Stephanie Searle et al., 2013)


³ Source: (OECD, 2004)

6.2.2 Potential synergies & benefits

Most of the residues produced during the crushing of oil seeds and extraction of oil, are used as feed and fodder. However, residues such as the husk of the oil seed can be used for different purposes and in different forms. In its primary form, it can be used as fuel in bioenergy plants, as well as for residential heating needs. In Greece and especially in Northern Greece there are several farmers or producers that prefer to use this type of biomass for heating purposes. However, due to technical problems when combusting it and its high logistic costs, sometimes this type of biomass must be transformed in different forms, like pellets. Because of the density of pellets, this format of biomass is much more easily transported or treated, thus leading not only to the reduction of the transportation costs but also it opens new markets for this kind of biomass.

6.2.3 Market developments


As it was abovementioned, the use of the husk that is annually produced in pellet form can help in the development of new markets for these by-products. These residues can be used for heat or electricity production. An indicative example consists a 1 MWe CHP plant in Greece (Biomassud plus, 2016) that uses residues from cotton seed as raw material to produce energy. Furthermore, pellets

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

coming from seed residues such as husks are sold in the fossil fuel markets as fuel for residential heating.

6.2.4 Non-technical barriers


The limited amount of seed cultivations in Greece along with the skepticism of Greek residents regarding the consumption of agro-residues as fuels in their houses instead of the “known” fossil fuels may create barriers for the current sector. The scarcity of available data and lack of communication among the stakeholder involved in the value chain makes it difficult to identify any further barriers.

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

7 SUMMARY ANALYSIS OF THE COUNTRY

Table 29. Summary sector “Olive Oil Mills”

Olive Oil Sector	
	Profile
Production	<ul style="list-style-type: none"> The main input product in this section is the fruit of the olive tree. In Greece there are two main types of olive oil mills: <ol style="list-style-type: none"> two-phase centrifugal mills and three-phase centrifugal mills Greek olive oil mills mostly use two-phase technology (60 %) rather than the three-phase technology (40 %). Olive mills’ residues (pomace) are sent to pomace mills for pomace oil extraction and other by-products.
Volume of the sector	<ul style="list-style-type: none"> Greek annual production ranges from 300,000 to over 400,000 t of olive oil per year. In 2014, the production of olive oil was at 241,400 t. Total cultivated area in Greece is around 0.8 million hectares of olive groves. The value of the produced olive oil is estimated at 800 M€ and contributes at 0.4 % of the national GDP (2010-2015). The recent years, the sector contributes more than 0.4 % of the GDP. 31.2 % of the total olive oil produced in Greece comes from Peloponnese, 24.8 % from Western Greece and 24.1 % from Crete. 2,500 olive mills, 35 pomace mills in Greece, 7 large scale and 3-4 small scale oil refineries. 36.5 % of olive mills in Peloponnese, 23.3 % of olive mills in Crete.
State of the sector	<ul style="list-style-type: none"> Only the 27 % of the Greek olive oil is distributed for domestic consumption and the rest (70 %) is exported (100,000 to 135,000 t). The total sales for economic year 2014 amounted to 832.7 million euros, 16.2 million euros lower than the previous year. After the historical low productivities/ sales of olive oil of years 2011-2014, current year (2017) has increased productions and sales.
Typical size of the companies	<ul style="list-style-type: none"> In Greece, olive mills are mostly owned by cooperatives controlled by farm owners. An average capacity for a typical Greek olive oil mill ranges between 200-230 t of olive oil production per year. A typical pomace mill has a capacity to treat 450-500 t of pomace/day. Around 15,000 seasonal workers in olive mills. Around 210 permanent workers and 875 seasonal workers in pomace mills.

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18


	Distinctive facilities of the sector	<ul style="list-style-type: none"> • Around 140,000 seasonal workers in farming and harvesting activities of olives.
	Degree of innovation	<ul style="list-style-type: none"> • Operation from September to March for olive and pomace mills. • Pomace mills larger than olive mills and more sophisticated. Better candidates for IBLC implementation. Several facilities could be available for implementing IBLC concept such as dryers, centrifuges and storage areas. • Facilities could be exploited in idle times with other raw material as alfalfa, clover etc., however additional equipment is needed.
	Opportunities for IBLCs	
	Sector related residues	<ul style="list-style-type: none"> • Three-phase annual productions→ Olive Pomace: 314.2 kt, Olive Oil Waste Water: 345-440 MI (year 2014 estimations). • Two-phase annual productions→ Olive Pomace: 754 kt, Olive Oil Waste Water: 0 (year 2014 estimations). • Greece produced 14 kt pomace oil, 135 kt exhausted olive cake available in the market (year 2014 estimations). • Estimated olive pruning production: 1.13-1.72 dry Mt. • Olive stones. • Olive leaves.
	Potential synergies & benefits	<ul style="list-style-type: none"> • Several treatment options are proposed in order to improve the decontamination efficiency of the OMWW. • Synergies with olive prunings, exhausted olive cake are feasible.
	Market developments	<ul style="list-style-type: none"> • Exhausted olive cake and olive stones can be sold in solid fuel market. • Phenols from exhausted olive cake (and leaves) can be used in pharmaceuticals industry, food industry. • Exhausted olive cake can be used in animal feed industries as well as the biogas industry. • Reuse of OMMW as fertiliser due to the organic matter and nutrients contained that could improve arid soils. • Olive prunings can find various applications such as production of pellets, particle boards or as fuel in power plants.
	Non-technical barriers	<ul style="list-style-type: none"> • Unwillingness of Greek citizens to have the pomace mills continue their operations during their idle times. They are unhappy with the

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

	<p>existing pomace mills facilities when operating due to odours and smoke (optical disturbance).</p> <ul style="list-style-type: none"> • Pomace mills are absent of national funding schemes, thus lack of funds for implementing new business concepts. • Difficulty of the solid fuel market to absorb exhausted olive cake as fuel for residential heating due to intense odours. • The production of olives and pomace as well, is climate-dependent. As a result, technologies for exploiting by-products and residues of the oil production process have not been yet developed.
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Table 30. Summary sector “Sugar Industry”

Sugar Industry	
	Profile
Production	<ul style="list-style-type: none"> • In Greece, sugar is produced primarily from sugar beet. • A tonne of sugar beet yields on average 17 % of its mass in sugar. • Most of the by-products (molasses, sugar beet) are used in feed and fodder.
Volume of the sector	<ul style="list-style-type: none"> • HSI (Hellenic Sugar Industry) is the only sugar producer in Greece. • In 2014, 53.4 kt sugar were produced from 2,360 beet growers. • Total cultivated land (2014): 7,400 ha. • The EU has put a production limit at 158,702 t of sugar/ year. • Intense fluctuation of the sugar production due to the unstable number of beet growers.
State of the sector	<ul style="list-style-type: none"> • In 2014, the annual turnover amounted to 90.6 M€ with an annual sugar production of 53,400 t. • The economic strength of the industry continuously decreasing due to low production (lowest in years) and the high production costs. • Farmers prefer other intensive crops (cotton, corn, sunflower, etc.), which (mainly cotton) enjoy higher subsidies from beet-growing. • According to the stakeholder the current year (2017) is the worst year regarding production of sugar and the market value of sugar for the last production year is only at 315 €/t.
Typical size of the companies	<ul style="list-style-type: none"> • Two sugar factories are still in use: i) Plati factory with capacity outputs around 100,000 t of sugar per year and ii) Orestias factory with capacity outputs around 60,000 t of sugar per year. • A third sugar factory in Serres (Northern Greece) with suspended operation. Every year the board of HSI decides whether it will work.

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

Distinctive facilities of the sector	<ul style="list-style-type: none"> • Distribution Network unit in Larisa (Thessaly region) with a beet gathering area and packaging unit. • In the factories of the Hellenic Sugar Industry are employed 220 people and around 280 more employees in the two subsidiaries companies in Serbia. The workforce is doubled during the production months (September to January) by hiring seasonal employees.
	<ul style="list-style-type: none"> • Operation from September to January. Many times the campaign starts from August. The rest of the year, maintenance of the equipment and facilities are carried out in order for the facilities to be ready and deal with the next import of products. • Several idle equipment to implement IBLC concept such as storage areas, feed handling, evaporators, dryers, pelletizers. • Current sugar factories operate with HACCP, attention is needed to the raw material that will be used in the idle equipment (food safety).
	<ul style="list-style-type: none"> • Research for the genetic improvement and creation of new sugar beet varieties acclimatized to the agro-climatic peculiarities of Greece. • Due to the economic crisis, investments on innovation are minimal.
Opportunities for IBLCs	
Sector related residues	<ul style="list-style-type: none"> • Molasses: 2-4 % of beet production. • Sugar-beet pulp pellets: 2-4 % of beet production. • Estimated annual beet production for the year 2013 around to 1,411,840 t → Molasses: 19.5 kt/year, Sugar beet pellets: 28.2 kt/year, Fresh pulp: 24.8 kt/year, Beet Leaves: 562.5 kt/year.
Potential synergies & benefits	<ul style="list-style-type: none"> • All the by-products resulting from the production of sugar cover the needs of industries and cattle-breeders in the internal market. • Molasses are used as a raw material to produce alcohol, yeasts and cattle feed. Sugar beet pulp pellets used as cattle feed.
Market developments	<ul style="list-style-type: none"> • Current by-products are used mainly in animal feed. • Molasses can be used as feedstock for ethanol production or biogas.
Non-technical barriers	<ul style="list-style-type: none"> • The current state of the sector is at bad weather (lowest production in recent years). • The economic crisis makes it difficult for investments to be performed.


	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

Table 31. Summary sector “Wine”

Wine sector	
	Profile
Production	<ul style="list-style-type: none"> The primary feedstock for the wine production is grapes and the end products are wines of different variety. The main by-products (grape marc) from the winemaking procedure are used as raw material for the distillery process or vinegar production.
Volume of the sector	<ul style="list-style-type: none"> In the wine-growing period of 2015-2016 the total wine production was 2,458,421 hl, 745,809 hl were red wine and the rest 1,712,432 hl were white wine. For the period 2015-2016 the total cultivated area was 62,723 hectares. The wine sector in Greece is estimated to consist of 1,100 wineries, 40 cooperatives and around 100 distilleries producing more than 7,000 labels. Greece produces 34 PDO (Protected Destination of Origin) labels and 120 PGI (Protected Geographical Indication) labels. 29.3% of the wine production comes from the region of Peloponnese while 20.16 % of the wine production comes from Attica and Central Greece.
State of the sector	<ul style="list-style-type: none"> The annual turnover for the 2017 economic year was 380 M€. In 2015-2016 the imports of wine were estimated at 33,863,007 € while the exports were 73,700,095 €.
Typical size of the companies	<ul style="list-style-type: none"> Total annual production capacity of the biggest winery in Greece reaches 2 million litres. Around 24,300 permanent workers are employed in the whole wine sector.
Distinctive facilities of the sector	<ul style="list-style-type: none"> Operation from October to February. The rest of the year, the facilities operate for the marketing of the wines (packaging, bottling and trade). Due to the complexity of process, perhaps equipment such as centrifuges, distillation columns and storage facilities can find further application.
Degree of innovation	<ul style="list-style-type: none"> Typical wineries do not operate with the state of the art machinery but they are trying to catch up with the latest developed technologies. Large wineries use the state of the art technology. Due to economic crisis, the sector does not invest much on innovation during last years.

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18


Opportunities for IBLCs	
Sector related residues	<ul style="list-style-type: none"> The main solid by-products and residues from the winery production are grape stalk, grape marc, wine lees and winery sludge (biosolids). Moreover, vineyard prunings consist a potential residue for the wine sector as well as the wastewaters coming from cleaning and wine production processes. Estimated annual by-products for 2015-2016: <ul style="list-style-type: none"> Grape stalks → 8.8 kt Grape marc → 35.4 kt Grape lees → 14.7 kt Wastewater → 487 Ml Estimated wine pruning production: 93-566 dry kt Leaves from vines.
Potential synergies & benefits	<ul style="list-style-type: none"> Use the wastes from wine distilleries as feedstock to produce platform chemicals, biofuels, and energy and fertiliser.
Market developments	<ul style="list-style-type: none"> Winery wastes can be used as feedstock to produce platform chemicals such as lactic acid, extract polyphenols (e.g. resveratrol) to be used in cosmetics, biofuels including ethanol, enzymes, chemical intermediates, and energy through pyrolysis and anaerobic digestion. Grape marc can be used as fertilizer. Vine prunings can be used as feedstock for energy plants or solid biofuels (pellets).
Non-technical barriers	<ul style="list-style-type: none"> Economic crisis has isolated companies for expanding their business plans. Lack of knowledge for exploiting agro-residues.

Table 32. Summary sector “Grain Chain”

Grain Chain Sector	
Profile	
Production	<ul style="list-style-type: none"> The most important grains that are cultivated in Greece are wheat, both soft and durum, barley, oats, rye and maize. By-products potentially suitable as biomass feedstock are generated during grain production, as well as during grain processing by industries.
Volume of the sector	<ul style="list-style-type: none"> The annual cereal production for the period 2015/2016 in Greece was 3,183,756 t. The cultivated area of cereals in Greece is 926,965 hectares. Total imports for 2015-2016: 1,706,355 t. Total exports for 2015-2016: 243,817 t.

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18


State of the sector	<ul style="list-style-type: none"> • The annual turnover for the year 2014 was 343,164 k€ • Greek grain sector has a decline during the last years due to the low profit margins and the economic crisis that Greece is facing with.
Typical size of the companies	<ul style="list-style-type: none"> • Around 800 flour mills and industries in Greece that produce and trade flour. • According to stakeholder feedback, around 3,000 permanent and seasonal employees, apart from the grain farmers, can be found in the whole grain chain sector. • The largest mill in Greece has a market share of 25 %.
Distinctive facilities of the sector	<ul style="list-style-type: none"> • Operation during the whole year. • Facilities like silos can be used to store different feedstock (e.g. wood chips) when there is availability.
Degree of innovation	<ul style="list-style-type: none"> • Sector invests in waste-management for zero-waste strategies. • Large companies exploit the produced residues to cover own energy needs. • Companies in the grain sector invest in technologies in order to be able to produce “functional” products, meaning products with better quality, with no diseases, without gluten etc.
Opportunities for IBLCs	
Sector related residues	<ul style="list-style-type: none"> • Main by-products during crops production: straws, stalks, stubble, corncobs, bran and husk. • 50,000 t of by-products each year produced by a typical cereal industry in Greece. • Estimated annual agro-residues (2015-2016) <ul style="list-style-type: none"> ○ Soft wheat straw → 352,975 t ○ Durum wheat straw → 785,657 t ○ Barley straw → 285,392 t ○ Maize stalks → 1,086,130 t ○ Maize cobs → 411,281 t ○ Oats → 65,400 t
Potential synergies & benefits	<ul style="list-style-type: none"> • Most agro-residues produced are totally consumed either as animal feed or for energy exploitation.
Market developments	<ul style="list-style-type: none"> • Straw can be used as raw material for pellets, bio-chemicals or biofuels.
Non-technical barriers	<ul style="list-style-type: none"> • No idle times for the available equipment and the amount of by-products produced are totally consumed either as animal feed or for energy exploitation. • Difficult for the farmers to give their agricultural residues (e.g. straw) to the IBLC as they incorporate them on their fields, adding organic matter to the soil. A synergy must be established between the grain farmers and the IBLC/ end user in order for the farmers to

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18


get something in exchange of the agro-residues, e.g. money to buy bacteria/ materials to increase the organic matter of their soils.

Table 33. Summary sector "Vegetable Oil Extraction"

Vegetable Oil Extraction	
	Profile
Production	<ul style="list-style-type: none"> Vegetable oil is extracted from various primary feedstock like cotton seeds, soya, sunflower, etc. Vegetable oil is used for edible use or for the production of biodiesel. Apart from vegetable oils, other products derive from these crops like seeds and fats that are used in animal feed.
Volume of the sector	<ul style="list-style-type: none"> In 2014 around 132 kt of vegetable oil was produced. In 2015 around 143 kt of vegetable oil was produced. In 2016 the production fell at 136 kt of vegetable oil. Three large scale vegetable oil extraction industries in Greece and some few more small-scale industries.
State of the sector	<ul style="list-style-type: none"> The vegetable oil sector in Greece is relatively small compared to other EU countries. For the last three years the sector can be characterized as stable.
Typical size of the companies	<ul style="list-style-type: none"> A Greek company that produces cotton oil has an annual production of 2,000 t seed oil. A typical vegetable oil company can operate 300-400 t of seeds/ day.
Distinctive facilities of the sector	<ul style="list-style-type: none"> Operation from September to April. If feedstock is imported, the facility may operate all year. Some equipment similar to the olive oil sector. Centrifuges, storage facilities, crushers can find various applications.
Degree of innovation	<ul style="list-style-type: none"> The vegetable oil extraction units use a simple technology, compared to pomace mills. No special R&D activities are performed on the vegetable oil sector in Greece.
	Opportunities for IBLs
Sector related residues	<ul style="list-style-type: none"> The primary use of vegetable proteins is that of animal feed. Seed residues from crushing (2016): <ul style="list-style-type: none"> groundnut → 6 kt soya → 268 kt rape → 7 kt sunflower → 48 kt cottonseed → 116 kt maize → 5 kt

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

<p>Potential synergies & benefits</p> <p>Market developments</p> <p>Non-technical barriers</p>	<ul style="list-style-type: none"> • Agro-residues from all the crop fields in Greece, not only from fields used for vegetable oil extraction (2014 crop production): <ul style="list-style-type: none"> ○ groundnut →7 kt ○ soya →20 kt ○ rape →9 kt ○ sunflower → 384 kt ○ cottonseed →1,641 kt ○ maize→ 1,303 kt
	<ul style="list-style-type: none"> • Currently, residues from crushing seeds are used in feed and fodder. • Husks of seeds and residues from crushing seeds can also be used as fuel or converted into pellets.
	<ul style="list-style-type: none"> • Agro-residues can be used as feedstock for energy production (power/ heat).
	<ul style="list-style-type: none"> • Limited seed cultivations. • Scepticism of residents regarding the consumption of such agro-residues in their houses.

	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

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	Reference:	AGROinLOG D6.2	Date:	29/05/18

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	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
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	Reference:	AGROinLOG D6.2	Date:	29/05/18

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	Document:	D6.2.2 Basic analysis of targeted agricultural sectors – Country report Greece		
	Author:	CERTH	Version:	Final
	Reference:	AGROinLOG D6.2	Date:	29/05/18

9 ANNEX A. CONSULTED STAKEHOLDERS

The following stakeholders were consulted:

- the executive director of KEOSOE (Central Cooperative Union of Wine Products) for the wine sector,
- the president of SPEL (Association of Olive Kernel Oil Producers of Greece), who provided data for the pomace mills as well as for the olive oil sector,
- the quality assurance manager of ELSAP S.A. (pomace mill in Nafplio, Southern Greece) who provided data on pomace mills as well as for the olive oil sector,
- the president of Agricultural Cooperative of Loukision (Central Greece) and owner of an olive mill,
- the president of Agricultural Cooperative of Agios Konstantinos (Central Greece), who provided data for the olive oil sector,
- the agronomist of LOULIS MILLS S.A., one of the most important Greek company in the grain chain sector,
- the president of AIXMEAS Agricultural Cooperative (Central Greece) who provided data for the grain sector,
- the representative of the Hellenic Sugar Industry who provided a clearer picture of the current state of the sugar sector in Greece and ,
- the financial manager of NUTRIA, an olive oil refinery plant that produces standardized olive oil, pomace oil and seed oils, who provided information on the vegetable oil extraction sector